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OPERATIONAL PLANNING DEBRIS REMOVAL

Final Report
July, 1971

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13. ABSTRACT

Procedures are established for predicting debris environments in urban areas resulting from different nuclear attack situations. Methods of classifying construction equipment by productivity for debris removal operations are presented, as are methods to estimate requirements for and mobilization of personnel and other supporting resources. Procedures include all pre-event planning activities, increased readiness requirements and implementation of clearing operations in the early post-attack period. Methods and procedures are illustrated by a hypothetical situation in the City of San Francisco.

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DETACHABLE SUMMARY

OPERATIONAL PLANNING

DEBRIS REMOVAL

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For

OFFICE OF CIVIL DEFENSE
OFFICE OF THE SECRETARY OF THE ARMY
WASHINGTON, D.C. 20310

By

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OPERATIONAL PLANNING - DEBRIS REMOVAL

Debris following a nuclear explosion can be predicted with procedures established in other studies. It is related to building size, construction and use as well as overpressures.

Routes along streets for post-attack emergency use will need to be cleared from 20 to 50 feet wide. Equipment and other resources must be mobilized as soon as possible. Many of the emergency routes will be required to be cleared within hours or a very few days to rescue survivors, prevent fire spread and re-establish emergency services.

Equipment and other resources should be inventoried, classified, and listed beforehand to expedite mobilization and to make an orderly plan of procedure for operation control. This includes plans for estimating supporting resource and supplies and accounting for them.

DEBRIS DESIGNATIONS

Debris has been classified to reflect the important characteristics that affect its removal. These are chunk or piece size, depth and structural content. Sixteen such classes are defined.

Unusual content which will vary with time or conditions of attack, must be known. One such problem will be automobiles. Such inclusions will require the normal debris classification to be revised.

CLEARING TASKS

There will be many emergency debris clearing tasks in any damage situation. Among other needs, routes will be required for rescue and fire fighting, evacuation, and access to essential facilities. The purpose of the route will determine its width, and three such route widths have been chosen as 20, 30 and 50 feet.

Debris removal for each task will be by dozing or load and haul or a combination of the two. These three methods are shown on a matrix with the three route widths to provide a code from 1 to 9 for type of operation.

Tasks can be numbered and listed. The list shows debris designation, traffic content and type of operation. It also shows physical characteristics required for estimating volume and resulting production requirements. These characteristics are width and length of route and average depth of debris. The time in which task should be accomplished is shown as is the task priority.

EQUIPMENT PRODUCTIVITY

Construction equipment most likely to be used is coded in terms of either horsepower or bucket capacity, whichever is appropriate. Standard production rates are given for each code for handling a uniform material such as well-blasted rock.

Debris will be more difficult to move than well-blasted rock. Variations in piece size and depth add to the difficulties as does inclusion of structural steel, building contents, and exterior objects. Factors have been determined for each of these elements which decrease production and are presented in a table for each debris type, for each type of equipment and traffic situation.

Production will be reduced further if more than one piece of equipment is used or if a single piece is used in a narrow route. Multiple unit factors for these conditions are shown for each type of major equipment.

These factors are applied to the standard production for all debris situations to arrive at reasonable production estimates.

DEBRIS ENVIRONMENT

Debris prediction surveys should be made of each debris zone prior to any emergency. These should be updated at least annually.

The surveys will list building height, size, construction, use and block coverage. It will show block sizes and street widths. The proposed survey form provides space for notation of trees and poles and comments on unusual conditions such as large numbers of billboards.

This survey can be made by patrolling each area. It can also be aided by use of several available maps such as Sanborn maps or city building code maps.

The proposed survey form can be used to predict debris volumes and types for various shock or overpressure conditions. A table is provided to show a relationship of building volume and use to its potential debris volume for blast only or for blast and fire. Another table shows average depth of debris factors for various block sizes in relation to street widths from 30 to 120 feet.

A chart shows the blast overpressure at which 20 building types experience light, moderate or severe damage. Moderate damage for all buildings occurs at less than 6 psi. Severe damage for a few does not occur until 11 psi but severe damage starts in most at less than 9 psi and in 3 types at less than 6 psi.

The important consideration for debris removal is that condition which creates debris in the streets. A table gives the factor for this for each building type for overpressures from 2 to 20 psi, where appropriate. Other tables show ratios of maximum to average debris depth, debris size under varying conditions, and ways to anticipate automobile inclusions.

AVAILABILITY OF REMAINING RESOURCES

Equipment yards of contractors, utilities, and mining companies, or others should be given serial numbers and an inventory made of each yard showing: shovels, front end loaders, dozers and motor graders by equipment

code number. These should be summarized by code numbers for each zone.

A cadre of equipment operators and operating management personnel should be listed with methods of contact and vital statistics on age, skills, etc.

Fuel and lubricant stock point locations, and methods of contacting them should be tabulated. Parts sources for the major manufacturers of equipment should be similarly listed.

Multipurpose staging areas (MSA) should be selected and shown and these will be those areas to which equipment not assigned will be gathered and from which it will be dispersed. This gathering of equipment at the MSA may start during the period of increased readiness.

EVALUATION OF CLEARING TASKS

Anticipated tasks can be listed for hypothetical situations and provisional priorities should be assigned. This will be done, recognizing that actual priorities must be established based on a great many variables after an event. The provisional priority system will provide an intermediate guide for ordering the assignment of resources. This report suggests guidelines for provisional priority assignment, based on urgency, number and condition of people and the chance of success of the mission.

MOBILIZATION

Mobilization will require a declaration of emergency, establishment of organization and housing, and ultimately movement of equipment from its base to the zone or task site where it will be used, or to a MSA.

Movement of equipment to a task site will require time to be added to removal production estimates. Zone to zone time tables will be needed and are illustrated. In some cases, uncontrollable fire or radiation may restrain

allocation of resources for all or part of a task.

ASSIGNMENT OF RESOURCES

Equipment from the inventory will be formed into effective groups which may be dissolved and reformed if required by tasks as they develop. The equipment groups will be coded and the code will show essential group characteristics.

The group card shows major and minor equipment and supporting resources of fuel, oil, grease and labor. It also shows standard production.

A task card is made for each task and nearby groups will be listed on it for production evaluation versus need. The most effective group will be assigned.

DETERMINATION OF TOTAL EFFORT

The task cards provide a source of information for resource needs. These can be summarized for the total task requirements.

A form is provided for the individual task managers to make a daily report of progress, unusual developments and details of all resources used.

A flow chart is provided to explain total pre-event organization of a debris removal operation.

PROBLEM SIMULATION

The proposed debris clearing operational plan is illustrated by means of an assumed attack on the City of San Francisco.

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<u>OCD Review Notice</u>: This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

PREFACE

This report on urban debris removal in an emergency situation has been prepared by Jacobs Associates of 500 Sansome Street, San Francisco, California under Contract No. DAHC 20-70-6-0305 dated 26 February, 1970 with the Office of Civil Defense.

This is a continuation of studies of debris generation and methods of handling debris. It is sponsored by the Office of Civil Defense. Cooperation has been helpful from Mr. Edward P. Joyce, Director Disaster Corps, City of San Francisco, Mr. William H. Van Horn of URS and Mr. Charles Rainey of Stanford Research Institute.

The contracting officer is Mr. Phillip H. Miller and the technical monitor is Mr. M. A. Pachuta, who has been most helpful.

ABSTRACT

This report is an analysis of use of available technology for a practical organization of conventional resources to accomplish the job of debris removal from emergency routes in an urban area following a nuclear explosion.

Detailed directions are given to predict debris quantity, particle size, variations in depth and distribution. A simplified method is provided to classify and code the debris into sixteen types.

Forms are provided for (1) inventory of essential resources; (2) grouping the equipment and estimating its needs in fuel, manpower and supporting tools. These procedures, if pre-planned, can provide control on the use of these resources during an operation.

Task requirement cards provide guidance in the use and selection of resources.

These procedures can be used in debris clearing operations, whether from natural or man-caused disasters.

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INTRODUCTION

Debris clearing operations may be a critical function in the early post-attack period. The purpose of this study is to provide a method by which potential debris environments can be predicted, and to present an operational plan for the efficient removal of debris from designated routes. Methods of evaluating clearing tasks, assigning appropriate resources, and determining total effort required are set forth. The study relates primarily to environments resulting from a nuclear attack but could be adjusted and used in considering other disasters such as hurricanes or earthquakes.

Overall recovery efforts include many aspects beyond the scope of this study. An attempt is made to show how debris clearing operations can be included in general emergency or disaster planning and to indicate the relative effect of debris clearing on other operations or functions.

Much of the information and data necessary to evaluate and specify debris clearing requirements have been presented in other research studies (References 1-7). This study has utilized and expanded applicable data in formulating the methods and procedures set forth herein.

Details are provided for both planning and operational control of debris clearing operations. Charts and tables delineate the various steps to be taken. They provide also input data necessary to evaluate the effects of different attack conditions on both debris environments and resource allocation.

To illustrate the proposed plan, a case study was made for the City of San Francisco using a simulated situation as might result from a "1 Mt air burst over City Hall". Results of the case study are given in terms of "total effort" required to clear debris from twelve designated routes through the City.

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SUMMARY

Debris following a nuclear explosion can be predicted with procedures established in other studies. It is related to building size, construction and use as well as overpressures.

Routes along streets for post-attack emergency use will need to be cleared from 20 to 50 feet wide. Equipment and other resources must be mobilized as soon as possible. Many of the emergency routes will be required to be cleared within hours or a very few days to rescue survivors, prevent fire spread and re-establish emergency services.

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SECTION I
DEBRIS DESIGNATIONS

1.1 INTRODUCTION

The rate at which various types of equipment will excavate, load or handle different materials is dependent on the following properties of the material:

1. Maximum size
2. Maximum depth
3. Uniformity of composition (content)
4. Average depth
5. Quantity and area configuration

Typical construction materials, such as rock, dirt, or gravel are fairly homogeneous and are usually distributed uniformly. Consequently, the production rates of equipment handling these materials can be determined readily. These rates indicate the average hourly production which could be expected in completing a task using specific kinds of equipment.

Debris will be composed of many different types and sizes of materials and will be encountered in various configurations and distributions. It is necessary, therefore, that certain criteria be established which will relate characteristics of debris to common factors useful in determining equipment productivity. The first three properties are: size, depth, and composition. These are discussed in this section. Section 2 deals with quantity and areal configuration. All must be considered in defining a particular clearing task.

Previous research (References 2, 3 and 4) has attempted to define the physical dimensions and composition of potential debris based on the type of construction and use of contributing buildings. Those studies considered the effects of both blast and fire damage to which a structure may be subjected

due to various attack conditions. They entailed the evaluation of theoretical analysis, actual observations at Hiroshima and Nagasaki and the results of physical tests conducted by the Office of Civil Defense and others. Continuing research is endeavoring to delineate, more specifically, the type, quantity and ultimate location (with respect to streets, etc.) of debris as it may be encountered in post-attack clearing operations.

1.2 DEBRIS CHARACTERISTICS AND CLASSIFICATION

Existing debris generation data is general with respect to size, mix, and type of material resulting from the destruction of buildings. Fourteen different types of debris were identified under prior research (Reference 1), defining these variable properties in terms compatible with the parameters of equipment productivity. These types were based on available research data, past experience with construction equipment operation and personal evaluations of anticipated debris characteristics. Three properties of debris considered were:

1. Maximum size - The predominant maximum size of pieces, excluding structural elements.
2. Maximum depth - The maximum depth to be encountered along a clearing path.
3. Structural content - Indication of the relative quantity of elements such as steel beams, large pieces of reinforced concrete, piping, trees, etc. in the debris. This factor was evaluated on the basis of added difficulties of handling debris caused by such inclusions and was designated as follows:

Content	Code
No steel or wood	1
Light steel - no wood	2
Medium to heavy wood; no steel	3
Medium steel	4
Heavy steel	5

Elements of reinforced concrete, piping, etc. are included in the general term of "steel". "Wood" includes trees and utility poles.

Subsequent study indicated that, with one or two exceptions, the 14 designations provided a reasonable basis by which debris properties could be related to equipment productivity. Exceptions included conditions where only minor quantities of debris (two to three inches, or less, in depth) would be encountered or where the predicted debris would be predominantly that from fallen trees or utility poles.

To accommodate all of the above possibilities, a revised debris designation table is shown in Figure 1.1. This table is essentially a narrative description of data which have been presented elsewhere in graphic form (Figure 1.3 of Reference 1). It designates debris types by a two-digit number. The first digit relates different combinations of debris sizes and depths as shown in the second and third columns of the table. The second digit delineates structural content. The table lists the various types of debris in order of anticipated degree of difficulty in handling during a clearing operation. Designation 1-1 is the least difficult and 6-5 is the most difficult. These designations will be used in subsequent determinations of clearing task requirements and are hereinafter referred to as "Parameter A" of the task definition.

In appraising the overall difficulty of accomplishing a clearing task,

DEBRIS DESIGNATIONS

Designation (Parameter A)	Range of Max. Size Inches	Range of Max. Depth Feet	Structural Content
1-1	1-6	0.1-1	None
1-2	1-6	0.1-1	Wood
2-3	7-14	1.1-3	Light Steel
3-1	15-30	3.1-6	None
3-2	15-30	3.1-6	Wood
3-3	15-30	3.1-6	Light Steel
3-4	15-30	3.1-6	Medium Steel
3-5	15-30	3.1-6	Heavy Steel
4-3	31-48	6.1-10	Light Steel
4-4	31-48	6.1-10	Medium Steel
4-5	31-48	6.1-10	Heavy Steel
5-3	49-60	10.1-15	Light Steel
5-4	49-60	10.1-15	Medium Steel
5-5	49-60	10.1-15	Heavy Steel
6-4	61-72	15.1-20	Medium Steel
6-5	61-72	15.1-20	Heavy Steel

Figure 1.1

it is necessary to consider not only the different physical properties of the debris but also the relative mix and consequent effect of each of the varying properties with respect to the others. A large quantity of debris consisting primarily of rubble from a brick building could be less difficult to clear than a relative small quantity of debris intermingled with steel girders.

The three factors considered reflect specific criteria necessary for the proper equipment selection and evaluation of productivity. Quantitative values for each of these factors can be estimated from debris generation research and confirmed by visual inspection of a devastated area in the early post-attack period. Discussion of possible methods and a procedural format by which pre-attack predictions of debris characteristics and type can be made is given in Section 4.

1.3 TRAFFIC CONTENT

It is likely that debris in streets and thoroughfares will contain damaged vehicles. Their presence could have a marked influence on the productivity or capabilities of equipment used in clearing operations. This type of inclusion is treated as a variable factor affecting debris types since it varies with respect to traffic, parking and other conditions existing at time of attack. This factor depends on the predicted number of vehicles which may be contained in the debris. It is referred to as "Parameter B" of the task definition. In accordance with this and paragraph 5.3 of Reference 1, this factor is defined as:

Traffic	Parameter B
Light	1
Medium	2
Heavy	3

As with other factors, their relative effect on the overall clearing operation varies with other physical properties of the debris. In areas with only small amounts of debris, the vehicles can be pushed aside with little additional effort. In other areas, their presence would affect the time required and increase the difficulty of accomplishing a task. Quantitative evaluation of this factor cannot be made other than to indicate, generally, the additional effort necessary to complete a clearing task in which damaged vehicles are encountered. The table given in Figure 1.2 is one method by which allowance for this factor can be made. In essence, it shows that the presence of damaged vehicles has the effect of classifying type of debris to a higher degree of difficulty.

The designations are sufficient to permit a reasonable determination of equipment requirements for various clearing operations to be conducted in the early post-attack period. Subsequent appraisal of the actual debris environment, through visual or other reconnaissance methods, may necessitate deviations from the planned operation, but such changes should not impair the possibilities of successful completion significantly.

The crucial element is the classification of debris conditions for determining necessary clearing requirements and for allocating the most appropriate equipment.

It would be impossible to allow for all possible debris types, but the designations in Figure 1.1, as modified by those in Figure 1.2, encompass those conditions most likely to be encountered in clearing operations. Many streets within an area may contain only minor quantities of debris requiring essentially no clearing before proceeding with other Civil Defense functions. Debris in other streets may make it virtually impossible to conduct or complete a clearing operation within the concept of "emergency" operations.

ADJUSTMENT OF DEBRIS DESIGNATIONS

TRAFFIC CONTENT

PARAMETER B

Debris Designation (Figure 1.1)	Adjusted Debris Designation Parameter B		
	Light (1)	Medium (2)	Heavy (3)
1-1	1-1	1-1	2-3
1-2	1-2	2-3	2-3
2-3	3-3	3-3	3-4
3-1	3-3	3-4	3-5
3-2	3-4	3-5	4-3
3-3	3-4	4-3	4-4
3-4	3-5	4-4	4-5
3-5	4-3	4-5	5-3
4-3	4-5	5-3	5-4
4-4	5-3	5-4	5-5
4-5	5-4	5-5	5-5
5-3	5-4	5-5	5-5
5-4	5-5	5-5	6-4
5-5	6-4	6-4	6-5
6-4	6-4	6-5	6-5
6-5	6-5	6-5	6-5

Figure 1.2

Standard debris designations serve several purposes. They enable a manager in charge of clearing operations to make early evaluations of potential problems and to allocate appropriate equipment accordingly. This concept is discussed later and is basically the process of identifying particular types and quantities of equipment with problems associated with specific types of debris. It would be similar to a construction manager who is informed that a certain job involving the removal of a considerable amount of rock is to be completed within a relative short period. He could appraise, immediately, the general type and number of units of equipment required.

Designating debris types by a two-digit number allows for early identification of major characteristics of the debris. The first digit indicates the general range or limits of particle size and depth of material. The second digit specifies the relative degree of difficulty in handling debris due to different types and quantities of structural or other inclusions. It also indicates supporting resources required to accomplish a task. For instance, a designation of 2 (Wood) implies that chain saws and similar tools will be required; a designation of 4 indicates that cutting torches probably will be needed. Additional effort required due to presence of damaged vehicles is indicated by Parameter B, and its effect on difficulty is indicated in Figure 1.2.

Since the designations show relative degrees of difficulty in accomplishing a task, it serves as a guide in the assignment of priorities on the basis of tasks showing the greatest possibility of successful completion within the limits of available resources and time.

Standard debris designations also serve the purpose of providing a common basis by which pre-attack plans and post-attack procedures can be equated. Subsequent sections discuss how this can be accomplished by relating equipment productivity and capabilities to the given designations.

SECTION 2
CLEARING TASKS

2.1 INTRODUCTION

The ultimate objectives of all Civil Defense debris clearing tasks can be described basically as one or more of the following:

1. Provide immediate access to or from specified locations for the implementation of emergency rescue and/or fire-fighting efforts.
2. Provide evacuation or supply routes.
3. Provide access to essential facilities.

Although there is an infinite number or combination of goals, objectives and conditions under which, or for which, these tasks must be accomplished, all have four common elements that are essential in the final determination of clearing operation requirements. These elements are:

1. Type of debris and possible inclusions to be encountered.
2. Type of operation, or method used in handling the debris.
3. Quantity of debris to be handled.
4. Time required for completion.

Each element must be considered with respect to the other in evaluating task requirements for assignment of appropriate available resources.

The purpose of this section is to define these elements in such a manner that general concepts can be applied to a wide variety of potential tasks. The format shown as Figure 2.1 is used to tabulate various values determined for particular tasks.

TASK DEFINITION

TASK NUMBER	PARAMETER										
	A		B	C	D					E	F
	TYPE OF DEBRIS		TRAFFIC CONTENT	TYPE OF OPERATION	DEBRIS QUANTITY					HOURS ALLOWED	PRIORITY
					d	w	W	L	V		
					Feet	Feet	Feet	1000 Feet	1000 Cu. Yd.		
	1	2			1	2	3	4	5		

Figure 2.1

2.2 TYPE OF DEBRIS AND TRAFFIC CONTENT

Various types of debris have been defined in Section 1. Figure 1.1 designates by a two-digit number the type of debris resulting from destruction of buildings, trees, etc. The applicable designation is noted for Parameter A of the format on Figure 2.1. Difficulty of handling such debris due to possible inclusion of damaged vehicles is taken from Figure 1.2. This effect is indicated as a relative value of: light (1), medium (2), or heavy (3), concentration of such vehicles. The numerical designation of 1, 2 or 3 is recorded as Parameter B.

2.3 TYPE OF OPERATION

There are two basic methods of handling debris that will be used in clearing operations:

1. Pushing debris aside (dozing)
2. Loading debris into trucks and hauling to disposal areas (load and haul)

Either, or a combination of the two, may be most appropriate for a particular task. Making such a determination would require an overall knowledge of the physical features along a route, such as: street widths and patterns; and the objective of the task, and the debris environment. General evaluations can be made. Routes through a predominantly single family residential area with wide streets would be cleared by dozing the debris aside. Clearing debris from a narrow street in the downtown area of a large city would require a load and haul operation. Deep debris in a wide street might best be moved by a combination of methods.

Decision as to the most appropriate type of operation will rest with the manager in charge of debris clearing operations. He must consider not

only the above factors but also the type and mechanical limitations of available resources.

Since the type of operation is essential in selecting the kind of major equipment for clearing debris, an evaluation is needed for pre-attack planning purposes as well as post-attack analysis.

Figure 2.2 identifies type of operation with different route widths (see paragraph 2.4.2). The manager can indicate the most appropriate type of operation. His choice is listed by code number from Figure 2.2 for Parameter C. Corresponding route width; 20, 30 or 50 feet, is noted for D-2.

Certain guidelines may be helpful in the use of Figure 2.2. Actual street width, D-3, will limit width of route to be cleared and will to a certain extent indicate the possibility of either dozing debris aside or the necessity of hauling debris from the clearing path.

As a general rule, dozers will be used wherever possible, particularly when debris is shallow and where there is room to windrow the dozed material. Load and haul operations may be required when debris is of appreciable depth or has to be moved for some distance.

2.4 QUANTITY OF DEBRIS

Time and equipment requirements for completing a task require estimates of the quantity of debris to be handled. Quantity (Parameter D-5) in this study, is defined in units of 1,000 cubic yards, based on average depth and length and width of route as explained below.

2.4.1 Length of Route

The length of a route (Parameter D-4) to be cleared can be estimated from the overall damage assessed and determination of the clearing objectives. In a moderate size city, there would probably be few or no tasks requiring a

TYPE OF OPERATION

PARAMETER C

WIDTH OF ACCESS ROUTE	METHOD OF HANDLING DEBRIS: BULLDOZING	COMBINATION	LOAD & HAUL
20 FEET	1	2	3
30 FEET	4	5	6
50 FEET	7	8	9

Figure 2.2

clearing route in excess of two miles. In a larger city, route lengths of three to five miles may be common.

Estimates of route lengths can be made during pre-attack planning. This would entail analysis of debris predictions, the evaluation of potential objectives, and determinations of most feasible or likely routes to be used in accomplishing or reaching those objectives. Each area would have different requirements. The best route may not be the shortest. A one-mile path through a heavily built-up section, with narrow streets, could require more effort and time than a more circuitous two-mile path through a less dense area to the same objective. If both paths would achieve the same objective, the longer route probably would be specified.

Length of routes are defined in this study in units of 1,000 feet.

2.4.2 Width of Route

The width of route (Parameter D-2) can be related to the prime objective of clearing task. Rescue operations for small groups would require the minimum width necessary for the passage of emergency vehicles or apparatus. A major group or facility evacuation route should be as wide as possible. Access needed for restoration of essential facilities would require provisions for two-way traffic of heavy vehicles. Widths of routes also relate to minimum working space requirements of equipment used in debris clearing.

Considering these factors, width of routes to be cleared for all Civil Defense operations will be specified as follows:

Objective	Route Width-Ft.
Emergency rescue	20
Access to essential facilities	30
Evacuation routes	50

During operations, the route length and width may vary from predetermined dimensions, as an equipment operator will follow the path of least resistance presented by the debris. The above indicated average measures of length and width would appear to provide a reasonable basis for estimating total quantity of debris and assignment of resources.

The width of route is indicated by Parameter C (type of operation) as either 20, 30 or 50 feet, and is shown on Figure 2.1 as Parameter D-2. The length of route, expressed in units of 1,000 feet is noted under Parameter D-4.

2.4.3 Average Depth and Quantity

Average debris depth is discussed in Section 4. The average depth, expressed in feet, is entered as Parameter D-1. Having determined the width, average depth and route length, it is possible to calculate total debris quantity to be handled in completing a task.

Most equipment production is rated in cubic yards per hour. Quantity of debris, therefore, is expressed in cubic yards. Figure 2.3 shows quantities of debris in terms of thousands of cubic yards per 1,000 foot of route length, depending on width of route, and average depth of debris.

Volume of debris in thousands of cubic yards for each task (Parameter D-5) can be obtained by multiplying the volume per 1,000 feet of route from Figure 2.3 by route length in thousands of feet (Parameter D-4).

2.4.4 Time for Completion and Priority

Emergency clearing operations must be completed in a specified time for achieving the objectives. Permissible time for completion depends on survival requirements, which in turn relate to attack conditions and resulting environments.

VOLUME OF DEBRIS

1000 cu.yd./ 1000 ft. of route

DEBRIS DEPTH FT.	ROUTE OF WIDTH - FEET		
	20	30	50
2	1.7	2.4	5.2
4	3.6	5.0	8.0
6	5.8	8.0	12.5
8	8.3	11.2	17.1
10	11.1	14.8	22.2
12	14.2	18.6	27.5
14	17.0	22.8	33.2
16	21.2	27.2	39.1
18	25.2	32.0	45.5
20	29.6	37.0	51.8

$V = .037\ (dw + d^2)$

where: V= Volume in 1000 cu.yd./1,000 ft. of route.

d = average debris depth in feet

w = route width in feet.

Figure 2.3

The actual time required for completing a task will have to be designated by the debris manager (in consultation with other related emergency groups) after he has assessed the overall damage, the resource, and specific situation or effect of the attack.

Although all tasks should be completed in the shortest possible time, the manager will, to a certain extent, be able to assign time intervals on the basis of priority. Priorities (Parameter F) are discussed in detail in Section 6. Generally speaking, tasks related to emergency rescue and fire fighting will be given top priority. Access to some essential facilities may not need to be completed for several days after shelter emergence.

The allowable time interval will be indicated for Parameter E in terms of hours. Clearing operations will be conducted on a 24-hour-day basis and production is measured on an hourly basis. Parameter E indicates time available for completing a task in hours. It serves two purposes:

1. Those tasks with least allowable time for completion will be given high priority with respect to allocation of available resources.
2. Attack evaluations may show that with available resources, a particular task cannot be completed within the specified time. Under such conditions, the manager may need to divert his resources to other tasks.

2.5 DIVISION OF TASKS

Defining clearing tasks by six parameters provides a common method by which all tasks for any area can be listed and evaluated for pre-attack planning and post-attack implementation. Values, or codes, assigned to each parameter will reflect as nearly as possible, the actual environment and corresponding resource requirements. In many instances, it may be found

that a single clearing route, necessary to achieve a specific objective, would pass through different debris environments. In such a case, the route may be divided into a number of tasks, each of which would define the predominant conditions of that portion of the total route.

The general format of defining clearing tasks is used in subsequent determinations of clearing operation requirements and total effort.

SECTION 3
EQUIPMENT PRODUCTIVITY

3.1 INTRODUCTION

Many variations of a few types of available construction equipment can be used for debris removal. Each general type, such as "bulldozer", includes many different makes and models each of which, within a size range, would have similar operating characteristics and performance capabilities. It is unlikely that each and every make or model could be assessed, individually, in pre-attack planning or in the post-attack period.

A table classifying typical equipment by type and horsepower or capacity has been prepared and is shown on Figure 3.1. A numeric code is used to identify specific units of equipment for subsequent determinations. For example, code "280" signifies a crawler type bulldozer of up to 150 HP rating. Codes are similar to those used in "Plan Bulldozer".

Classes of equipment are also indicated as either major or minor. Major equipment is dozers, shovels, loaders and motor graders. All other is "minor" equipment. Primary consideration of debris removal will be based on capacity or production of major equipment.

Minor equipment indicates auxiliary equipment necessary for certain operations. For instance, dump trucks are needed for a load and haul operation, although actual production will be based on the capacity of the major equipment which is the shovel or loader being used.

Figure 3.1 shows a great variety of equipment, some of which may not be adaptable to specific debris clearing tasks, nor even available for consideration in a particular area. A variation to the table should be prepared to reflect local conditions. There would be an advantage to having some standard to the coding as under attack condition, one city or area may borrow resources from another.

CLASSIFICATION OF EQUIPMENT - CODES

Horsepower Rating or Capacity	Major Equipment									Minor Equipment									
	Class 1		Class 2				Cl. 3	Class 4		Class 5		Class 6		Class 7		Class 8		Cl. 9	Cl. 10
	Bulldozer		Front End Loaders				Motor	Shovels		Clamshell		Backhoe		Scrapers		Cranes		Trucks	Misc.
			End Dump		Side Dump		Grader							Self	Self				
	Crawl	Wheel	Crawl	Wheel	Crawl	Wheel	Wheel	Crawl	Wheel	Crawl	Wheel	Crawl	Wheel	Propel	Load	Crawl	Wheel		
To - 150 HP	280		160	161	170	171	141												
151-200 HP	282	283	162	163	172	173	143												
201-250 HP	284	285	164	165	174	175	145												
251-300 HP	286	287	166	167	176	177													
Over 300 HP	288	289		169		179													
1/2 to 1 Cu. Yd.								260	261	080	081	020	021						
1.1 to 1-1/2 Cu. Yd.								262		082	083								
1.6 to 2 Cu. Yd.								264		084	085								
2.1 to 3 Cu. Yd.								266		086	087								
1.1 to 2 Cu. Yd.												022	023						
2.1 to 5 Cu. Yd.												024	025						
5.1 to 10 Cu. Yd.								268			089			251	255			311	
10.1 to 15 Cu. Yd.														253	257			313	
15.1 to 20 Cu. Yd.																		315	
To 10 Ton																070	071		
10 to 20 Ton																072	073		
Over 20 Ton																074	075		
Low Bed Truck																		317	
Service Truck																		751	
Tire Truck																		753	
Fuel & Lube Truck																		755	
Sweeper																			757
Grp. 1 Comp. & Air Tools																			600
Group 2 - Light Plants																			602
Grp. 3 Hnd. Tools etc																			620
Group 4 - Metal Cutting																			621
Group 5 - Wood Cutting																			622

Figure 3.1

3.2 STANDARD PRODUCTION RATES

Production rates, or rates of handling typical construction materials such as rock, gravel, or dirt have been determined for various types of construction equipment. These rates vary with type of material, characteristics of equipment being used and job conditions. A similar evaluation or rating can be made for equipment handling debris. Allowances must be made for variations of the physical properties of debris as compared to those of a common construction material such as "well-blasted rock".

The table on Figure 3.2 lists the average hourly rate of handling well-blasted rock for types of major equipment listed on Figure 3.1, which are those most likely to be used as major tools in any debris removal task. The production rate is shown in terms of loose cubic yards per hour under each equipment code classification.

The indicated production rates are based on working at depths and under conditions to afford maximum production efficiency for the type of equipment. They are based on a 50-minute working hour. These production rates are referred to as "standard production". They assume that supporting equipment and supplies are provided and this is discussed in Section 5.

3.3 PHYSICAL PROPERTIES EFFECT ON PRODUCTION

The physical properties of debris, which must be considered in adjusting standard production by a single piece of equipment, are:

1. Maximum Size
2. Maximum Depth
3. Structural Inclusions or Content (including trees and poles)
4. Average Depth
5. Traffic Content (damaged vehicles)

STANDARD PRODUCTION

Major Equipment			Item	Code & Standard Production Cu.Yd./Hr.				
Bulldozer		Crawler	Code Rate	280 140	282 230	284 330	286 400	288 520
Bulldozer		Wheel	Code Rate		283 190	285 275	287 350	289 530
Front End Loader	End Dump	Crawler	Code Rate	160 100	162 140	164 185	166 245	
Front End Loader	End Dump	Wheel	Code Rate	161 130	163 185	165 250	167 330	169 430
Front End Loader	Side Dump	Crawler	Code Rate	170 125	172 190	174 215	176 290	
Front End Loader	Side Dump	Wheel	Code Rate	171 155	173 220	175 300	177 400	179 525
Motor Grader		Wheel	Code Rate	141 160	143 200	145 280		
Shovel		Crawler	Code Rate	260 80	262 160	264 220	266 260	268 320
Shovel		Wheel	Code Rate	261 80				

Figure 3.2

Necessary adjustments are expressed as a percentage of standard production. They are made by evaluating the relative overall effect of these properties of debris with corresponding properties of well-blasted rock. The effect of variables on standard production differs with each type of equipment.

Section 4 of Reference 1 shows basic adjustments of standard production to be made to reflect the different debris properties. Those adjustments have been revised in accordance with new debris designations and requirements as set forth in this report and combined into one composite factor as shown in Figure 3.3.

The three equipment types shown are dozers, front-end loaders and shovels. Motor graders were not shown as they can be used as prime equipment only in situations where their production will be fairly optimum or close to the standard production. Such tools as back hoes and clamshells are not shown as their main use will be in spot or unusual situations where production factors would have little meaning.

The current analysis showed that the debris designation - Parameter A - (described in the first two sections of this report) reflects all of the physical characteristics of debris for averaging except "traffic content" or Parameter B. The type (Parameter A) does reflect differences in debris size, depth, variations in depth and structural inclusions.

As a result, Figure 3.3 gives 9 adjustment factors for each of the 16 debris types. There are 3 each for the three equipment types to provide a factor for each of the three values of Parameter B.

The combined factor may be used as in the following example. A clearing task requires the removal of debris type (Parameter A) 3-4. There was a moderate amount of traffic, so Parameter B is 2. The available resource is a 350 HP crawler bulldozer - Code 284 (Fig. 3.1). Its standard production

COMPOSITE ADJUSTMENT FACTORS

Debris Designation (Parameter A)	Parameter B								
	Bulldozer			Front End Loaders			Shovels		
	1	2	3	1	2	3	1	2	3
1-1	1.00	1.00	.86	.97	.97	.86	.48	.48	.47
1-2	.93	.86	.86	.87	.86	.86	.47	.47	.47
2-3	.75	.75	.72	.72	.72	.71	.43	.43	.42
3-1	.75	.72	.71	.72	.71	.69	.43	.42	.41
3-2	.72	.71	.59	.71	.69	.58	.42	.41	.41
3-3	.72	.59	.57	.71	.58	.53	.42	.41	.40
3-4	.71	.57	.53	.69	.53	.51	.41	.40	.38
3-5	.59	.53	.43	.58	.51	.47	.41	.38	.32
4-3	.53	.43	.40	.51	.47	.45	.38	.32	.29
4-4	.43	.40	.33	.47	.45	.36	.32	.29	.24
4-5	.40	.33	.33	.45	.36	.36	.29	.24	.24
5-3	.40	.33	.33	.45	.36	.36	.29	.24	.24
5-4	.33	.33	.22	.36	.36	.25	.24	.24	.16
5-5	.22	.22	.16	.25	.25	.18	.16	.16	.12
6-4	.22	.16	.16	.25	.18	.18	.16	.12	.12
6-5	.16	.16	.16	.18	.18	.18	.12	.12	.12

Figure 3.3

from Figure 3.2 is 330 cu.yd./hr. From Figure 3.3 the factor for dozers in 3-4 debris with type 2 inclusions is 0.57. Production of this bulldozer will be 330 x 0.57 = 188.1 or 188 cu.yd./hr.

A rather convenient way to use these factors is shown in Figure 8.1 and discussed in Section 8 of this report.

3.4 MULTIPLE UNIT PRODUCTION FACTORS

The adjustment factors, previously discussed, reflect the use of a single unit of major equipment with no restrictions from limited working space due to width of clearing route, etc. They do not allow for the fact that many clearing tasks will be accomplished by using several units or a combination of different types of equipment working as a group.

These two conditions of space and multiple equipment use, impose additional limitations on the anticipated hourly production rates. A shovel or loader cannot work efficiently unless there is sufficient room to turn and load the hauling vehicles. Two bulldozers working side by side, in a restricted area, cannot obtain double the maximum production of a single unit, due to interference between the two units.

Figure 3.4 shows a table of factors to reflect the effect of these space conditions on hourly production. In the example in paragraph 3.3, the adjusted hourly production rate for a bulldozer, Code 284, has been determined to be 188 cu.yd./hr. Assuming a 50-foot wide path and the need for two units the total production for the pair would be 188 x 1.7 = 319.6 cu.yd./hr. It would not be 376, as would be indicated by multiplying 188 by 2 units. Blanks left in the various columns of the table show that it would not be practical to use the multiple number of the indicated units for that particular route width.

MULTIPLE UNITS

COMBINATION FACTORS

	Width of Route - Ft.	50 Feet			30 Feet			20 Feet		
	No. of Units	1	2	3	1	2	3	1	2	3
TYPE OF EQUIPMENT	Bulldozer	1.0	1.7	2.1	1.0	1.6	2.0	1.0	1.3	
	F.E. Loader E.D.	1.0	1.2		1.0	1.2		.6		
	F.E. Loader S.D.	1.0	1.8	2.0	1.0	1.5		.9	1.2	
	Motor Grader	1.0	1.6		1.0	1.6		.8		
	Shovel	1.0	1.2		0.7			.5		
	Clamshell	1.0			0.7					
	Backhoe	1.0	1.2		1.0	1.1		0.6		
	Scraper	0.8			0.6					

Note: F.E. = Front End
E.D. = End Dump
S.D. = Side Dump

Figure 3.4

3.5 OTHER EQUIPMENT

Construction equipment for any job requires certain support equipment such as fuel trucks, tire trucks, and sometimes air compressors, with paving breakers or drills. Sometimes cutting torches, or chain saws may be needed. Nearly always, small hand tools such as shovels, wheelbarrows, crow bars, sledgehammers, axes, and safety equipment as hard hats, raincoats and boots will be required. These supporting resources are required to achieve the production rates discussed above. When all of these are put together, they normally are called an "equipment spread" or in this study, a "group". These groups are defined in Section 8 of the report. Generally speaking, the production capability of a group is related directly to the adjusted capability of either the single or multiple principal major equipment units of the group as described in this section.

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SECTION 4
DEBRIS ENVIRONMENT

4.1 INTRODUCTION

Debris environment, as used in this section, relates to the physical composition, depth and overall configuration of debris which may be anticipated, or actually encountered during post-attack clearing operations. Since most operations will be directed toward the clearing of streets and thoroughfares, the debris in the streets or "off-site" debris is that which is considered.

Although various research studies have defined debris environments expected in certain areas due to different attack conditions, it would be unrealistic to expect that any pre-attack determinations would accurately predict actual conditions. This is due primarily to the uncertainty of the size, location and height of detonation. Previous studies do, however, provide a basis for making general approximations of the potential debris environments.

Post-attack visual reconnaissance of the damaged area will provide the most reliable appraisal. It would include the compilation of various damage assessments, reported to a central control center, from different areas or zones within the attack perimeter. This information will permit an overall evaluation of the actual environment; probably in terms of light, moderate or severe damage. It would not, however, be available for the immediate implementation of clearing operations.

Since time is critical, a procedure is essential to use common measurements of debris environment for relation to removal resources in pre-attack and post-attack periods.

4.2 DEBRIS PREDICTION SURVEY

The first determination in the planning process is to make some evaluation of potential debris environments resulting from possible attack

conditions in the planning area. Quantitative evaluations of environments, usually expressed as "contours" of debris depth, have been made in other research studies (Reference 7). The "contours" generally were defined by the extrapolation of debris conditions as determined for individual structures.

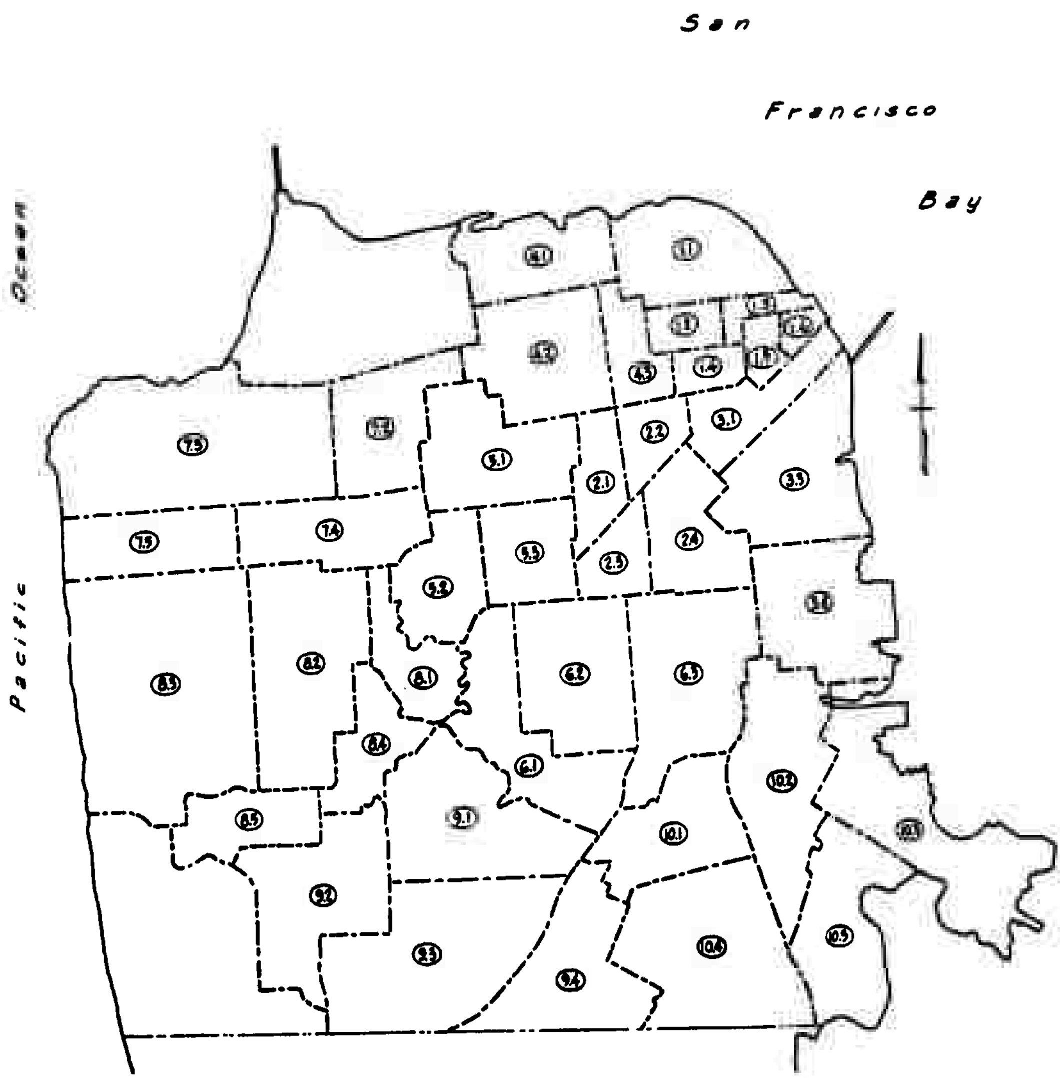
The following procedure of making debris predictions for pre-attack planning purposes was arrived at after review and consideration of the methodology developed in previous studies. The proposed format is such that determinations can be adjusted readily to conform to actual post-attack reports on real conditions. It includes generalizations and assumptions which may be verified or modified, as the case may be, by continued research. The procedure is referred to as a "Debris Prediction Survey" or, for brevity, a "D.P.S.".

Appropriate zone maps will be needed for the survey area. Zones should reflect, as nearly as possible, areas within which a uniform debris environment could be expected due to similarity of buildings and area configurations. In some cases, local planning officials may choose zones already established for other purposes, such as fire districts. For purposes of illustration, an area zone map of the City of San Francisco is shown in Figure 4.1.

A D.P.S. sheet, as shown in Figure 4.2, is prepared for each zone to record data necessary for the survey and ultimate determinations. The first step would be to complete input data A through H, as indicated on the upper portion of the D.P.S. sheet. These data reveal average existing conditions in the zone and can be obtained from visual inspection and use of available Sanborn (or other) maps, building records, etc. The team (probably two men) making the survey should be cognizant of the survey requirements and capable of identifying types of building construction and use.

Data for the D.P.S. will be recorded showing:

AREA ZONE MAP
CITY OF SAN FRANCISCO



Note: (1.2) indicates zone number.

Figure 4.1

________ - ZONE NO. ________

(A) Block Size ________ (B) Street Width ________ (C) Building Coverage ________ (D) Ave. Bldg. Height ________

(E) Building Type ________ (F) Building Use ________ (G) Trees - Poles ________

(H) Comments ________

(I) E.B.S. ________ (J) Contained Vol. ________ (K) Material Factor: Blast ________; Blast and Fire ________

(L) Potential Debris Material: Blast ________; Blast and Fire ________ (M) Ave. Depth Factor ________ (N) C ÷ B ________

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1) Incident Over-Pressure PSI	(2) Damage Light-L Moderate-M Severe-S	(3) Off Site Factor	(4) Vol. Off Site Debris Cu.Ft./Lin.Ft	(5) Average Depth Feet	(6) Ratio Maximum To Average Depth	(7) DEBRIS DESCRIPTION: Maximum Depth	(8) DEBRIS DESCRIPTION: Maximum Size	(9) DEBRIS DESCRIPTION: CONTENTS: Building	(10) DEBRIS DESCRIPTION: CONTENTS: Trees Etc.	(11) PREDICTED DEBRIS TYPE
BLAST ONLY											
BLAST AND FIRE											

Figure 4.2

Item A. Block Size - Average block size within the zone is recorded from among the following six block sizes:

100 ft. x 300 ft.

200 ft. x 200 ft.

200 ft. x 300 ft.

300 ft. x 300 ft.

300 ft. x 400 ft.

400 ft. x 400 ft.

For different or unusual shaped blocks, the choice would usually be of one with the closest total area.

Item B. Street Width - Width of street is the average distance between faces of buildings, including sidewalk areas. Widths from 30 to 120 feet are to be used in increments of 10 feet.

Item C. Building Coverage - A determination is made of the percentage of block areas that are occupied by buildings. In many cases, this will be an estimate by the surveying group. In a residential area, buildings may occupy only 20 to 40% of the total block area. The percentage in commercial areas may approach 100%.

Item D. Average Building Height - Average height is the average of all buildings within the zone. An exceptionally tall, isolated building should not be averaged, but should be noted under "comments" on the D.P.S. sheet.

Item E. Building Type - Building type reflects the predominant type of building construction and is recorded by number. The table on Figure 4.3 lists 20 building types considered in this study. They are essentially the same as set forth in Reference 2.

Item F. Building Use - Typical use of most buildings is indicated as residential (R), commercial (C), or industrial (I).

Item G. Trees and Poles - Indication is made of size and number of trees or utility poles adjacent to streets and which could contribute to "off-site" debris. This input will be a relative evaluation designated as "none", "medium" or "heavy".

Item H. Comments - Any predominant factors or physical features that could affect clearing operations are noted. These could include an exceptionally high or massive building; a large number of metal standards and signs; and possibly an evaluation of potential traffic conditions to be expected during different hours of the day.

If a zone does not lend itself to "averaging" as indicated above, it may be necessary to divide the zone into smaller increments and a new D.P.S. sheet prepared.

With the above data provided for each zone, it is then possible to make a determination of possible debris environments which might be expected within the zone due to various attack conditions. The proposed procedure and necessary calculations to make such a determination are described in the following paragraphs.

TYPES OF BUILDINGS

Type No.	Description
1	Wood Frame
2	Unreinforced Masonry Load - Bearing Wall
3	Light Steel Frame Industrial - Corrugated Asbestos Sheathing
4	Light Steel Frame Industrial - Corrugated Metal Sheathing
5	Medium Steel Frame Industrial - Corrugated Asbestos Sheathing
6	Medium Steel Frame Industrial - Corrugated Metal Sheathing
7	Heavy Steel Frame Industrial - Corrugated Asbestos Sheathing
8	Heavy Steel Frame Industrial - Corrugated Metal Sheathing
9	Multistory Heavy Reinforced Concrete Shearwall - Light Interior Panels
10	Multistory Heavy Reinforced Concrete Shearwall - Masonry Interior Panels
11	Multistory Reinforced Concrete Shearwall - Light Interior Panels
12	Multistory Reinforced Concrete Shearwall - Masonry Interior Panels
13	Multistory Steel or Reinforced Concrete Frame - Light Exterior Panels - Non Earthquake
14	Multistory Steel or Reinforced Concrete Frame - Masonry Exterior Panels - Non Earthquake
15	Multistory Steel or Reinforced Concrete Frame - Light Exterior Panels - Earthquake
16	Light Reinforced Concrete Frame - Masonry Exterior Panels - Earthquake
17	Light Reinforced Concrete Shearwall - Concrete Roof - Light Interior Panels
18	Light Reinforced Concrete Shearwall - Concrete Roof - Masonry Interior Panels
19	Light Reinforced Concrete Shearwall - Mill Type Roof - Light Interior Panels
20	Light Reinforced Concrete Shearwall - Mill Type Roof - Masonry Interior Panels

Figure 4.3

4.3 BUILDING AND CONTENT DEBRIS

The principal source of debris will be from the buildings, and their contents, that are either totally or partially damaged by the attack. Sources, from outside the buildings, such as trees, utility poles, automobiles, etc., are considered later. The type and quantity of debris generated from buildings is dependent on the following:

1. Size, or contained volume of the building.
2. Type of building construction.
3. Principal use of the building.
4. Attack conditions.

Other factors, such as direction of the blast wave and shielding effect of other buildings probably could be considered in making a detailed debris analysis of an area. Consideration of the above listed factors is believed to be sufficient to give a realistic "first approximation" of actual debris type and quantity.

Previous research studies have determined quantitative values for the various factors to be considered. They are:

1. Factors are given for determining quantity of structural materials within a building which would form debris. The factors are expressed as a percentage of the total contained volume of a building and vary according to type of construction (20 types on Figure 4.3 previously mentioned). (Reference 3)
2. Factors are given to determine the material volume of building contents such as: desks; cabinets; furniture; etc., which would contribute to debris. These factors are based on the floor area or size of the building and

the primary use of the building such as: residential; commercial; or industrial. (Reference 3)

3. Factors show the percentage of total structural or content material that would be converted into "debris" as a result of various attack conditions. (Reference 2)

4. Factors are given for the amount of total debris that would remain on-site and the amount that would be thrown off-site. (Reference 4)

The above factors have been developed for both "blast only" and "blast and fire" conditions.

4.4 EQUIVALENT BUILDING STRIP (INPUT I - FIGURE 4.2)

Off-site debris is related directly to the type and use of buildings that front on the street and the contained volume or size of such buildings. The type, use and average height of the buildings within a zone will have been determined and noted on the D.P.S. sheet. It is also necessary to know the building's length and width to determine its contained volume. The length, as measured along the street frontage, is taken as one foot for these calculations. The width (or depth) of the building is the average width of a hypothetical building of uniform width along the total street frontages of the block. It is determined from the ratio of actual building coverage in the block to the total area of the block.

This building width is termed the "Equivalent Building Strip" (or E.B.S.). It indicates the average width of a hypothetical building which would contribute the same amount of debris to the street as would all of the actual buildings in the block. As an example, assume a 300' x 300' block, or one of 90,000 square feet total area. The actual building coverage is 30% of the total block area, or approximately 27,000 sq.ft. A hypothetical building

around the 1,200 feet perimeter of the block with a width, or E.B.S., of 25 feet, would approximate the total actual coverage of all buildings in the block.

Figure 4.4 gives the E.B.S. for the six block sizes considered in this study as determined by different percentage of building coverage. By using data inputs A (block size) and C (building coverage) from the D.P.S. sheet, an E.B.S. factor can be determined for input "I" (E.B.S.) and noted accordingly on the D.P.S. sheet.

4.5 CONTAINED VOLUME (INPUT J - FIGURE 4.2)

The contained volume of buildings which would contribute debris to the streets, can be determined by multiplying the average building height (Input D) by the E.B.S. Since length of the building along the route is considered as one foot, the volume is expressed as cubic feet per lineal foot.

4.6 MATERIAL FACTORS (INPUT K - FIGURE 4.2)

The amount of debris generated is a function of actual quantities of material used in building construction plus the material in the contents of the building. Other studies show the quantity of structural material in a building as a percentage of the total contained volume of the building. This percentage varies with different types of construction. Studies also have been made which indicate the material volume of typical building contents as a percentage of the size, or contained volume, of the building. These factors vary with the primary use of the building, such as residential, office, etc. Examples of the structural and content factors are given in Reference 3. That study designates factors for these variables for both "blast only" and "blast and fire" conditions.

EQUIVALENT BUILDING STRIP
(E.B.S.)

% of Bldg. Coverage	SIZE OF BLOCK -- FEET: 300 by 100	200 by 200	300 by 200	300 by 300	300 by 400	400 by 400
10	4	5	6	8	9	11
20	8	11	13	16	18	21
30	12	16	20	25	28	33
40	16	23	27	34	39	45
50	21	30	35	44	50	59
60	26	37	44	55	63	73
70	30	46	54	68	77	90
80	37	56	65	84	94	110
90	43	68	79	103	115	136
100	50	100	100	150	150	200

$$\text{E.B.S.} = \frac{(L \times W)^{1/2} - [LW(1-C)]^{1/2}}{2}$$

Where L = Length of Block, Ft.

W = Width of Block, Ft.

C = Percentage of block covered by buildings (Expressed as a decimal)

Figure 4.4

Multiplying the contained volume by the appropriate factors will give an approximation of total quantity of material which could form debris under different attack conditions.

This study has combined and related the various factors to 20 typical building types on the basis of predominant use. The structural factors are based on those given in Reference 3. Equivalent content factors were derived to approximate the different mixes of building types and uses which might be expected in an urban area. All factors were adjusted so that they could be applied to the contained volume of the buildings.

The sum of the structural and content factors, expressed as a percentage of the contained volume, indicates the quantity of material (solid measure) within the buildings which would contribute to the formation of debris. To convert this quantity of material to equivalent volumes of potential debris, a factor of 2 is used. This is based on an estimated average void ratio for debris of 1:1. The table on Figure 4.5 is a list of debris factors determined for different uses of the 20 typical buildings. It lists factors for both "blast only" and "blast and fire" conditions. Some of the listed building types probably would not be used for all three of the indicated occupancies, therefore, no factor is given for those improbably occupancies. All factors in Table 4.5 have been adjusted for the debris void ratio of 1:1.

Knowing the building type (Input E) and use (Input F), the debris factors can be obtained from the table and noted on the D.P.S. sheet as Input K. Separate factors will be noted for each condition - "blast only (B)" or "blast and fire (B & F)".

4.7 POTENTIAL DEBRIS MATERIAL (INPUT L - FIGURE 4.2)

The quantity of building and content material, which could generate debris under various attack conditions, is obtained by multiplying the

DEBRIS FACTORS
BUILDING VOLUME x FACTOR GIVES POTENTIAL DEBRIS VOLUME

Building Type	BLAST ONLY Res.	BLAST ONLY Com.	BLAST ONLY Ind.	BLAST & FIRE Res.	BLAST & FIRE Com.	BLAST & FIRE Ind.
1	.218	.354		.026	.076	
2	.378	.494	.390	.186	.230	.216
3	-	.164	.188	-	.040	.052
4	-	.158	.182	-	.034	.046
5	-	.162	.188	-	.040	.052
6	-	.160	.184	-	.036	.048
7	-	.166	.190	-	.042	.054
8	-	.160	.184	-	.036	.048
9	-	.380	.456	-	.216	.242
10	-	.460	.536	-	.296	.322
11	.276	.406	.290	.132	.180	.162
12	.376	.506	.390	.230	.278	.260
13	.256	.392	.138	.116	.164	.146
14	.330	.466	.350	.190	.238	.220
15	.270	.406	.290	.130	.178	.160
16	.350	.486	.370	.208	.256	.238
17	.280	.340	.320	.134	.168	.172
18	.290	.350	.330	.148	.182	.186
19	-	.274	.254	-	.102	.106
20	-	.300	.280	-	.132	.136

Note: Res. = Residential; Com. = Commercial; Ind. = Industrial

Figure 4.5

contained volume of the building by the debris factors from Figure 4.5. Since the contained volume is that of a hypothetical building, in one foot of route length, the volume of potential debris material, so obtained, is expressed in cubic feet per lineal foot of route and recorded as Input L. Two entries are made. One is for the condition of "blast" and the other for "blast and fire".

4.8 AVERAGE DEPTH FACTORS (INPUT M AND N - FIGURE 4.2)

The method above provides a means to estimate the total volume of debris from destruction of buildings of known volume, type and use. Quantities would depend on attack conditions. The debris would be distributed in varying depths over areas including: the building site; adjoining block; frontage street areas; and possibly portions of adjacent side streets. It is impossible to predict details of the debris distribution.

The average depth is required in evaluating clearing operations. It is used in determining the total quantity of debris and in equipment selection and productivity estimates. The table on Figure 4.6 lists "average depth factors" for the specific block size (Input A) and street width (Input B), and are noted (as Input M). Discussion in 4.10 explains how this factor is multiplied by off-site debris volume to give an average depth estimate.

Maximum depth also needs to be estimated. A means to estimate this is described in 4.10 and requires a ratio of building height (Input D) to street width (Input B) and this ratio (D/B) is inserted as Input N on the D.P.S. sheet.

4.9 PREDICTING DEBRIS ENVIRONMENTS

The various zone characteristics and factors, previously discussed, show pre-attack conditions, ascertained from visual inspection, use of

AVERAGE DEPTH FACTOR

Width of Street Ft.	SIZE OF BLOCK - FEET					
	300 by 100	200 by 200	300 by 200	300 by 300	300 by 400	400 by 400
30	.026	.020	.023	.021	.023	.021
40	.019	.015	.017	.015	.017	.016
50	.015	.011	.013	.012	.013	.012
60	.012	.009	.011	.010	.011	.010
70	.010	.008	.009	.008	.009	.009
80	.009	.007	.008	.007	.008	.007
90	.008	.006	.007	.006	.007	.006
100	.007	.005	.006	.005	.006	.006
110	.006	.004	.005	.005	.006	.005
120	.005	.004	.005	.004	.005	.005

Figure 4.6

available debris generation data, city maps, or other similar data or processes.

The next determination to be made is the potential debris environment which might be anticipated in a zone as a result of different attack conditions. The following indicates how this can be done.

The numbered columns of the D.P.S. sheet are used for guidance. Determinations are made for both "blast only" and "blast and fire" conditions.

Incident overpressures, to which an area or zone may be subjected, are listed in Column 1. The range of overpressures would be considered limited, to a certain extent, by the particular building type of the zone. For instance, overpressures above 5 or 6 psi would not be considered for a wood frame building since total destruction occurs at a somewhat lesser value.

Column 2 denotes the degree of damage corresponding to the various overpressures listed in Column 1. This evaluation of damage is shown as light (L), moderate (M), or severe (S). It does not reveal the specific structural damage to a building but rather the approximate level of destruction by which significant quantities of debris are expected to be generated.

It is likely that initial post-attack reconnaissance reports will be general in nature. They will indicate, probably, only a relative degree of damage which may suggest quantities of debris. If a "moderate" damage report was received from a particular zone, the approximate incident overpressure experienced in the zone could be bracketed by the range of moderate damage, shown in Column 2. For subsequent determinations, the highest overpressure listed in the "moderate damage range" would be used. (See discussion of zone situations, paragraph 4.12.)

The table of Figure 4.7 shows the relation between building types, incident overpressures, and degree of damage. The range of damage and corresponding overpressures were derived from data presented in other studies

DEGREE OF DAMAGE - DEBRIS GENERATION

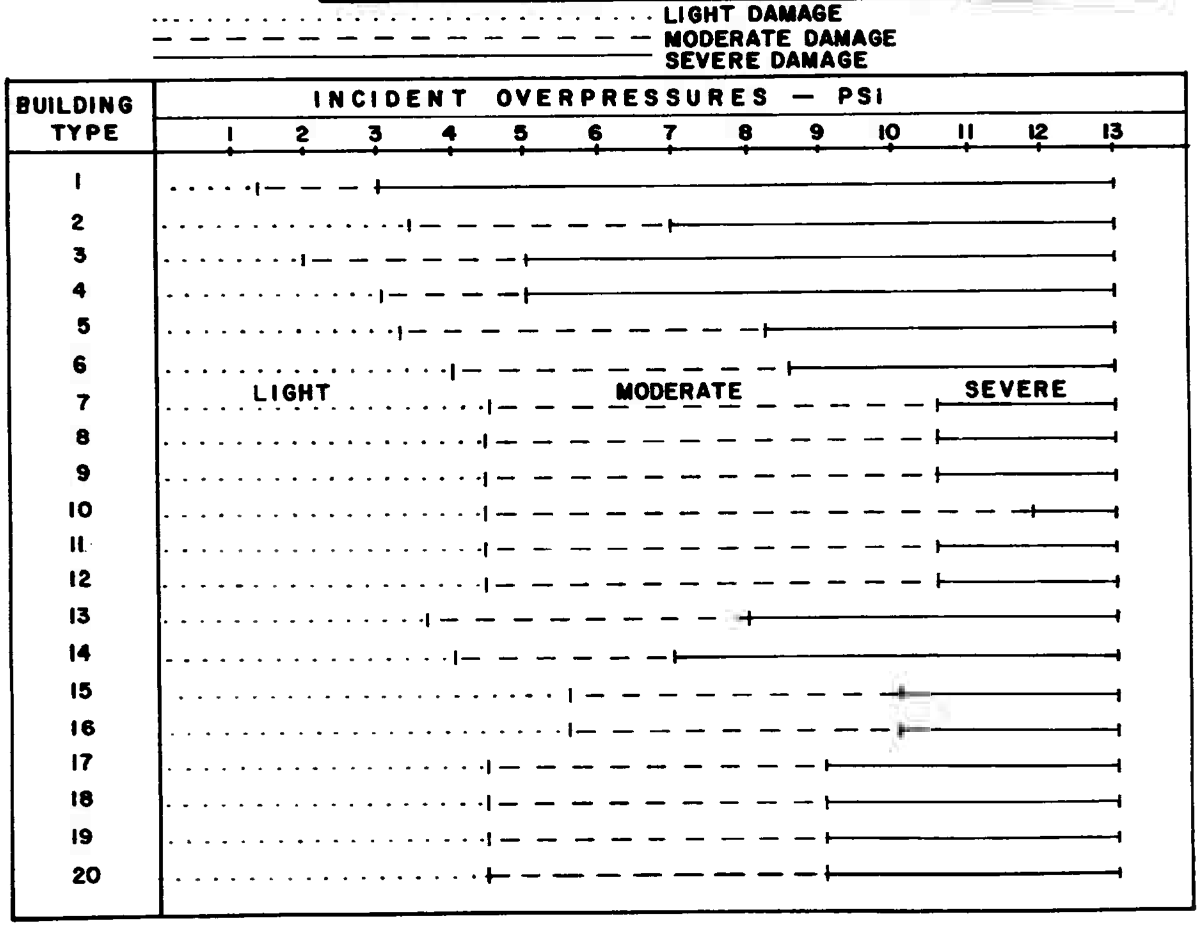


FIGURE 4.7

and were adjusted to reflect "damage" as related to debris generation.

The same overpressures and corresponding damage evaluations are used for both "blast only" and "blast and fire" conditions.

4.10 OFFSITE DEBRIS FACTOR

Input L (Potential Debris Material) is an indication of the total volume of debris which could be generated from typical buildings. The actual quantity will depend on type of building construction and the attack conditions. A portion of the debris will remain on-site, the remainder will be trajected onto adjoining areas. The ultimate quantity and distribution depends primarily on the incident overpressure. Considering volume generated and its distribution, with respect to the 20 different building types, a table of off-site debris factors is given in Figure 4.8. The applicable factor for the particular type of building and incident overpressure is obtained from the table and noted in Column (3) of the D.P.S. sheet. The same factor is used for like overpressures under both conditions of blast or blast and fire. The anticipated volumes of off-site debris, Column (4), is obtained by multiplying Input L ("B", or "B & F" as the case may be) by this factor and noted as cu.ft. of debris per lineal foot of frontage.

The off-site debris will be spread over the adjacent street areas. An indication of the average depth is, the quantity in Column 4 multiplied by average depth factor, Input M. As previously discussed (in 4.8) this factor allows for variations in total area over which the debris may be spread. The product is noted in Column 5 as feet of depth.

The actual area distribution of debris could vary from a few scattered pieces to large piles of rubble and structural members several tens of feet high. Allowance for this type of distribution must be considered in the evaluation of clearing requirements. It entails the consideration of incident over-

OFF SITE DEBRIS FACTOR

Bldg. Type	Overpressure psi 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	.034	.274	.500	.600										
2	0	0	0	.007	.050	.180	.540	.600							
3	.200	.100	.40												
4	.053	.220	.30												
5	.170	.40	.40												
6	.025	.10	.15												
7	.003	.30	.40												
8	.025	.10	.15												
9	.003	.008	.010	.027	.033	.043	.067	.080	.113	.130	.150	.170	.180	.200	.220
10	0	0	.005	.017	.042	.072	.116	.161	.218	.289	.361	.400	.430	.500	.500
11	0	.003	.008	.017	.028	.043	.068	.081	.112	.141	.150	.160	.170	.180	.190
12	0	0	.006	.025	.053	.056	.144	.217	.280	.301	.400	.400	.500	.500	
13	0	.006	.018	.041	.072	.105	.162	.200	.225	.250	.300				
14	0	0	.019	.073	.106	.165	.443	.550	.600	.400					
15	0	.002	.009	.025	.041	.072	.105	.145	.200	.250	.300	.300			
16	0	0	.010	.040	.085	.176	.296	.402	.510	.600	.500				
17	0	.001	.006	.012	.012	.030	.228	.510	.550	.600	.600				
18	0	0	.018	.072	.154	.230	.421	.648	.800	.800					
19	0	.033	.132	.300	.350	.400	.600								
20	0	.084	.121	.289	.500	.550	.650								

Figure 4.8

pressures, height and size of buildings, width of streets and direction of the blast wave.

It would be impossible to predict exactly how the debris would be distributed. In an effort to make some evaluation, the following general assumptions were made with respect to maximum variations from the average depth indicated above:

1. The greatest variations will occur at relatively low overpressures in areas with wide adjoining streets.
2. Variations will decrease as overpressures increase and/or as width of streets decrease.

"Variations" as referred to above can be expressed as a ratio of maximum depth to average depth. The table on Figure 4.9 shows ratios of maximum to average depth for different ratios of building height to street width (Input N) and variations in overpressures.

These are relative values with respect to quantities and average depth of debris. A ratio of 6:1 in an area where average depth is 2 ft. implies occasional piles of debris approximately 12 ft. deep. The same ratio in areas with average depths of 5 ft. indicates 30 ft. maximum depth. Using Input N, appropriate ratios can be listed in Column 6 for the different overpressures considered. Pressures beyond 1:1 ratio imply levels at which for all practical purposes, uniform distribution occurs.

4.11 DEBRIS PROPERTIES

The physical properties, which basically define type of debris or debris environment and ultimately clearing tasks, are:

1. Maximum Size
2. Maximum Depth
3. Structural Content

RATIO OF MAXIMUM DEPTH TO AVERAGE DEPTH

Bldg. Ht.-St. Width D/B-Input(N)	Incident Overpressure								
	2	3	4	5	6	7	8	9	10
.2	12:1	10:1	6:1	6:1	5:1	4:1	3:1	2:1	1:1
.4	12:1	10:1	6:1	5:1	4:1	3:1	2:1	2:1	1:1
.6	10:1	8:1	6:1	5:1	4:1	3:1	2:1	1:1	
.8	8:1	6:1	5:1	4:1	3:1	2:1	1:1		
1.0	8:1	5:1	5:1	4:1	3:1	2:1	1:1		
1.2	6:1	5:1	4:1	3:1	2:1	1:1			
1.4	6:1	4:1	3:1	3:1	2:1	1:1			
1.6	6:1	4:1	3:1	2:1	2:1	1:1			
1.8	5:1	4:1	3:1	2:1	2:1	1:1			
2.0	5:1	4:1	3:1	2:1	2:1	1:1			
2.5	5:1	3:1	3:1	2:1	1:1				
3.0	5:1	3:1	2:1	2:1	1:1				
3.5	4:1	3:1	2:1	2:1	1:1				
4.0	4:1	3:1	2:1	1:1					
4.5	3:1	2:1	2:1	1:1					
5.0	3:1	2:1	1:1						
6.0	3:1	2:1	1:1						
8.0	3:1	2:1	1:1						
10.0	2:1	2:1	1:1						

Figure 4.9

4. Average Depth

5. Quantity and Area Configuration

The D.P.S. offers a means by which properties can be estimated for various zones on the basis of assumed, or actual attack conditions. Knowing the approximate average depth, it is possible to determine total quantity of debris to be handled for a specific task. Multiplying average depth by the ratio noted in Column 6 gives an indication of maximum depth which is shown in Column 7. Maximum and average depths and total quantity basically define the distribution and contours of debris to be encountered in clearing operations.

The maximum size is the largest size of debris pieces, excluding large structural components such as beams, girders, etc. It varies with type and use of building and degree of destruction. Previous research studies have given descriptions of potential debris. These descriptions relate primarily to structural failures and possible mix of elements. They do not give quantitative values. It is necessary that at least a general approximation of maximum size and content be made during the pre-attack planning process since these two factors are essential in the overall evaluation of clearing operations.

The table of Figure 4.10 shows values of size and content determined in this study. The designated values are intended to reflect the proportionate mix of building and content materials for a particular building type and use depending on incident overpressure or degree of damage. The content rating provides a measure for evaluation of difficulty, as might be experienced in handling the debris due to large structural inclusions (see discussion, Section 1). No distinction is made between "blast only" and "blast and fire" conditions, although such a refinement may be desirable. It is doubtful that the size and/or content of off-site debris would be materially altered due to

MAX. SIZE DEBRIS

STRUCTURAL CONTENT

Bldg. Type	Light Damage						Moderate Damage						Severe Damage					
	Resid.		Commer.		Indus.		Resid.		Commer.		Indus.		Resid.		Commer.		Indus.	
	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC
1	3	1	6	1	-	-	14	2	20	3	-	-	30	2	30	3	-	-
2	18	1	24	1	24	3	30	1	30	3	24	3	30	1	36	3	36	4
3	-	-	12	3	12	3	-	-	24	3	30	4	-	-	30	3	48	4
4	-	-	12	3	12	3	-	-	24	3	30	4	-	-	40	3	48	4
5	-	-	6	3	18	3	-	-	48	3	60	4	-	-	60	5	72	5
6	-	-	6	3	18	3	-	-	48	3	60	4	-	-	60	5	72	5
7	-	-	6	1	24	3	-	-	48	4	60	4	-	-	72	5	72	5
8	-	-	6	1	24	3	-	-	48	4	60	4	-	-	72	5	72	5
9	-	-	36	3	36	3	-	-	60	4	48	4	-	-	72	5	72	5
10	-	-	24	3	36	3	-	-	60	4	48	4	-	-	72	5	72	5
11	30	3	30	3	36	3	48	4	60	4	72	5	72	5	72	5	72	5
12	30	3	30	3	36	3	48	4	60	4	72	5	72	5	72	5	72	5
13	30	3	36	4	48	4	48	3	60	5	60	5	60	4	72	5	72	5
14	14	3	30	3	36	3	30	3	48	4	48	4	48	5	60	5	60	5
15	14	1	24	3	24	3	30	3	48	4	48	4	30	5	60	5	60	5
16	14	1	30	3	30	3	30	3	48	4	48	4	48	5	60	5	60	5
17	30	3	36	3	36	3	48	3	48	4	48	5	60	4	72	5	72	5
18	30	3	36	3	36	3	48	3	48	4	48	5	60	4	72	5	72	5
19	-	-	24	3	36	3	-	-	36	3	48	3	-	-	60	5	60	5
20	-	-	24	3	36	3	-	-	36	3	48	3	-	-	60	5	60	5

Abbreviations: S = Size in inches; CC = Content Code (See Section 1).

Figure 4.10

fire conditions. Exceptions would be debris from wood structures which may be consumed by fire or where massive buildings adjacent to narrow streets might collapse as result of fire. Values from the table of Figure 4.10 are noted in Columns 8 and 9.

Relative quantity and size of trees and poles which may be contained in the debris are noted in Column 10. This indication will be in accordance with discussions in paragraph 1.3 and can be based on "comments", (Input H), of the D.P.S. sheet.

The predicted debris type is indicated in Column 11 and is determined by relating values given for maximum size, depth and content with debris designations shown in Figure 1.1. It should reflect most difficult mix as indicated by the given values. Figure 4.11 shows a completed D.P.S. sheet.

The debris type is representative of the "fixed" physical features of a zone and does not allow for possible inclusion of damaged vehicles. Evaluation of this variable factor is discussed in paragraph 1.3. Although comments listed on the D.P.S. sheet will help in determining this factor, it is proposed that a separate tabulation of anticipated traffic conditions be prepared for the various zones. Such a tabulation is shown for a hypothetical situation on Figure 4.12. This tabulation will provide values for Parameter B, when severity (zone situation) and time of attack are known or assumed. Severity will have been classed for the zone by debris management by a code from Figure 4.13 which is discussed in Reference 1 and the following paragraphs.

4.12 EVALUATION OF ACTUAL DEBRIS ENVIRONMENTS

The D.P.S. sheet indicates potential debris types and environments which might be expected in a particular zone as a result of different attack conditions. The environments are listed in accordance with the two direct

DPS Sheet - ZONE NO. 3.1

(A) Block Size 300 x 300 (B) Street Width 70' (C) Building Coverage 60% (D) Ave. Bldg. Height 140'

(E) Building Type 12 (F) Building Use C (G) Trees - Poles None

(H) Comments

(I) E.B.S. 55 (J) Contained Vol. 7700 cf (K) Material Factor: Blast .506 ; Blast and Fire .278

(L) Potential Debris Material: Blast 3896 cf ; Blast and Fire 2140 cf (M) Ave. Depth Factor .008 (N) D ÷ B 2.0

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1) Incident Over-Pressure PSI	(2) Damage Light-L Moderate-M Severe-S	(3) Off Site Factor	(4) Vol. Off Site Debris Cu.Ft./Lin.Ft	(5) Average Depth Feet	(6) Ratio Maximum To Average Depth	(7) DEBRIS DESCRIPTION: Maximum Depth	(8) DEBRIS DESCRIPTION: Maximum Size	(9) CONTENTS: Building	(10) CONTENTS: Trees Etc.	(11) PREDICTED DEBRIS TYPE
BLAST ONLY	2	L	0	-0-	-						
	6	M	.096	374	3.0	2:1	6.0'	60"	4	-	4-4
	12	S	.400	1558	12.5	1:1	12.5'	72"	5	-	5-5
BLAST AND FIRE	2	L	0	-0-	-						
	6	M	.096	205	1.6	2:1	3.2'	60"	4	-	3-4
	12	S	.400	856	6.8	1:1	6.8'	72"	5	-	4-5

Figure 4.11

VARIABLE CONTENT

ZONE SITUATIONS

(TRAFFIC CONDITIONS)

Zone No.	Zone Situation *	Time and Day of Week: 10 PM - 6 AM, Week Days	10 PM - 6 AM, Week End	6 AM - 9 AM / 4 PM - 6 PM, Week Days	6 AM - 9 AM / 4 PM - 6 PM, Week End	Other, Week Days	Other, Week End	Warning Activities, All Days
		Values for Parameter B						
1	1,2,4	1	1	1	1	1	1	1
	3,5,6	1	1	2	1	1	1	2
	7,8,9	1	1	2	1	1	1	2
2	1,2,4	1	1	1	1	1	1	2
	3,5,6	1	1	2	1	1	1	2
	7,8,9	1	2	2	2	1	1	2
3	1,2,4	1	1	1	1	1	1	1
	3,5,6	1	1	2	1	1	1	1
	7,8,9	1	1	2	1	1	1	1
4	1,2,4	2	2	3	1	2	1	3
	3,5,6	2	2	3	1	2	2	3
	7,8,9	2	2	3	1	2	2	3
5	1,2,4	1	1	1	1	1	1	1
	3,5,6	1	1	2	1	1	1	1
	7,8,9	1	1	2	1	1	1	1
6	1,2,4	1	2	3	1	2	1	3
	3,5,6	1	2	3	1	2	1	3
	7,8,9	1	2	3	1	2	1	3
7	1,2,4	1	1	1	1	1	1	1
	3,5,6	1	1	2	1	1	1	2
	7,8,9	1	1	2	1	1	1	2

* See Figure 4.13

Figure 4.12

ZONE SITUATIONS

DEBRIS ENVIRONMENTS

	Negligible Fire Damage	Moderate Fire Damage	Severe Fire Damage
Light Blast Damage	1	4	7
Moderate Blast Damage	2	5	8
Severe Blast Damage	3	6	9

Figure 4.13

measures of the intensity of a nuclear detonation which are incident overpressures and fire spread. If values indicative of the actual attack conditions can be determined for these two factors, then it would be possible to identify the post-attack environments for each zone. Both factors are dependent on:

1. Yield of weapon
2. Type of blast (surface or air)
3. Geographic location

The extent of the fire spread also is dependent on building types and other physical features of the particular area.

Other research studies have developed criteria for measuring the effects or extent of damage caused by the detonation of different types of nuclear weapons. Incident overpressures usually are indicated by isobars of pressure radiating from ground zero. Fire spread is determined for specific weapons and area configurations.

Although this study is not involved in any aspect of weapon evaluations, it is assumed that it would be possible to construct typical patterns of damage for a variety of detonations, i.e., a 5 megaton surface blast or a 20 megaton air blast, etc. Individual patterns of the most likely weapons should be drawn on transparent overlays to the same scale as used for area zone maps. See Figure 4.14 as an example.

Early post-attack reports will indicate the approximate yield, type and location of the blast. The appropriate damage pattern overlay will be placed over the area zone map with ground zero centered at approximate location given by the reports. Incident overpressures can then be determined for the various zones by identifying corresponding isobars from the overlay. The approximate fire spread also can be indicated. Knowing these two factors,

DAMAGE PATTERN

5 Mt . AIR BURST

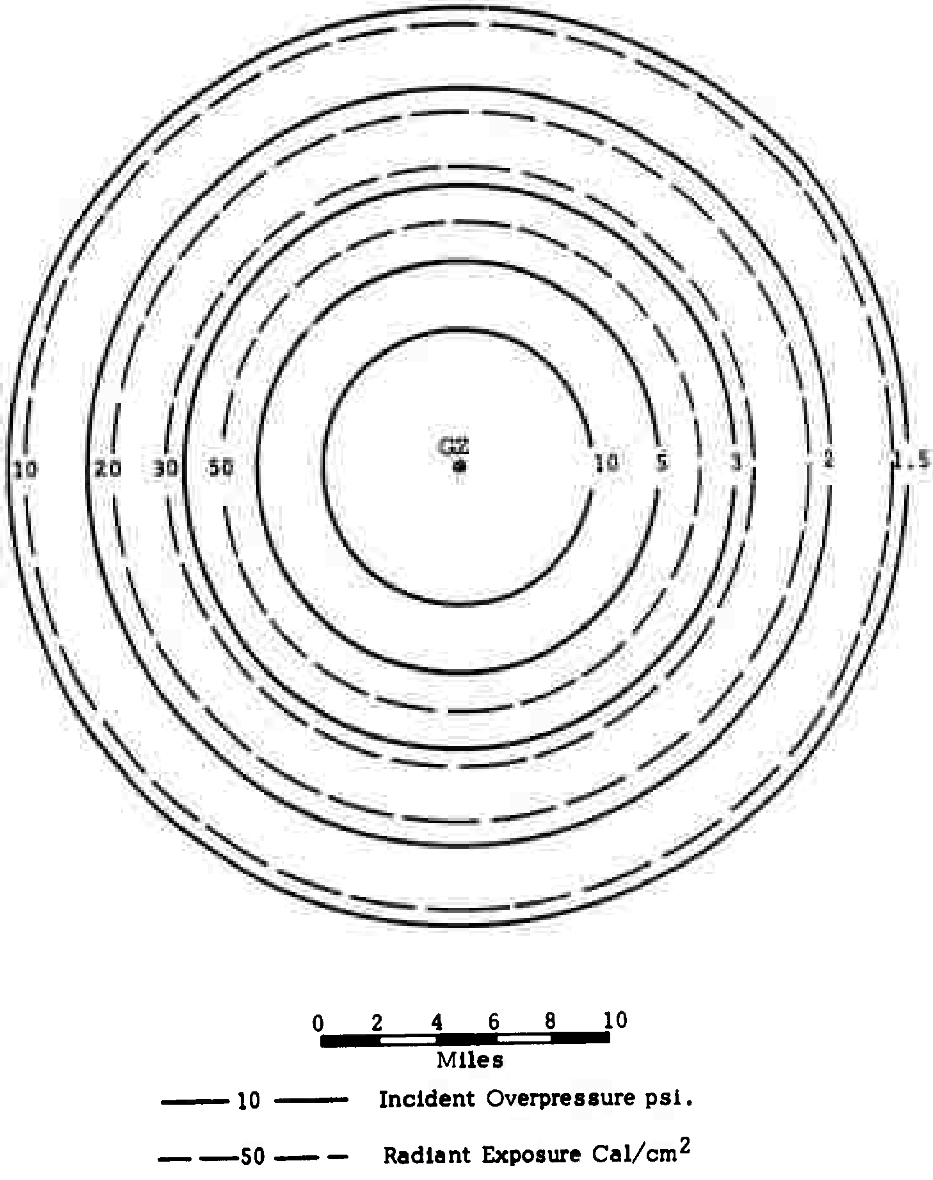


Figure 4.14

a reasonable determination of post-attack environment can be made from data contained on the D.P.S. sheet.

Another method of identifying the actual environment would be by use of "zone situations" as discussed in paragraph 5.3 of Reference 1. This would require individual evaluations of overall damage experienced in each zone. Damage reports, or zone situations, would indicate the degree of both blast and fire damage in accordance with that data shown on Figure 4.13.

A zone situation of 2 (moderate blast damage) could be related to damage evaluations given in Column (2) of the D.P.S. sheet. Situation 2 indicates negligible fire damage so the environment would be based on "blast only" conditions.

Both methods indicate the general range or degree of damage sustained by the attack. The most difficult environment within the indicated range would be used in initial evaluations of clearing operations. If necessary, the environment parameters could be adjusted, to reflect more detailed damage assessments which may be reported subsequently.

The proposed procedure for making pre-attack and post-attack evaluations of actual debris environments entails the use of many factors which have been determined in other research studies. If, or when, more appropriate values for these factors are determined, they could be substituted for values used without changing the overall concept. A general appraisal of the proposed D.P.S. method could be made by comparing specific area environments, as determined herein, with environments as defined for the same areas in other research studies.

SECTION 5
AVAILABILITY OF REMAINING RESOURCES

5.1 INTRODUCTION

The inventory of all available basic resources is fundamental to the success of any construction job. Debris removal is a form of construction job.

The principal resources are:

1. Equipment
2. Personnel
3. Fuel and Lubricants (P.O.L.)
4. Repair Parts
5. Equipment Transport Facilities.

Debris removal resource control need not be a complicated and time-consuming operation with large masses of records. The availability of these resources is constantly changing in any area. For example, operating personnel for this type of work, generally, are very mobile and follow construction activity from one geographic area to another. Parts and P.O.L. supplies, held locally, will vary with types of current jobs and the level of construction activity in the area. Fortunately, organizations are available which maintain records of such things as labor and equipment parts. There are fewer reliable sources of information on heavy construction equipment census.

The procedures outlined in this section are directed towards a very simple but reliable utilization, and extension, of existing information. The inventory must be in such a form that it can be used to collect resources at designated areas during period of increased readiness. The concept and use of multipurpose staging areas (MSA) for ultimate deployment of resources has

been considered in other emergency plans. How it relates to debris removal resources is discussed in Section 7.

5.2 EQUIPMENT RESOURCES

The main inventory function of the debris removal task force will be to control key equipment elements. An inventory must be made of all local, and nearby, sources of usable equipment in the key categories. This equipment list has been abbreviated so that it can be maintained reliably with minimum effort. This approach will lead to greater accuracy and dependability than would result from an effort to tabulate and control every type of equipment that may be employed.

An inventory will be made only of equipment of the type and size ranges essential to this operation. It will include only: bulldozers; shovels; front-end loaders; motor graders; dump trucks and low bed trucks for hauling the equipment. The table on Figure 5.1 shows this selected key equipment, classified and coded for inventory. The coding follows the format described in Section 3 of this report.

Figure 5.2 shows a form which will be completed at each source, or storage location, of the equipment shown in Figure 5.1.

The main equipment sources will be contractors, quarries, utilities, government agencies (municipal, county, state and federal) equipment dealers (including rental companies), and nearby mining operations. Each source will have a serial number for their location or storage yard or job where the equipment is based. The serial or identifying number is entered on the upper right hand corner of Form 5.2. A separate inventory will be made for each equipment base or storage location, even though the same owner may control several such bases and, therefore, be shown on several sheets.

EQUIPMENT INVENTORY CODE

ITEM		CAPACITY OR HORSEPOWER	CODE CRAWLER	CODE WHEEL
BULLDOZER		0-150 HP	280	
		151-200 HP	282	283
		201-250 HP	284	285
		251-300	286	287
		Over 300 HP	288	289
FRONT END LOADER	END DUMP	100-150 HP	160	161
		151-200 HP	162	163
		201-250 HP	164	165
		251-300 HP	166	167
		Over 300 HP	-	169
	SIDE DUMP	100-150 HP	170	171
		151-200 HP	172	173
		201-250 HP	174	175
		251-300 HP	176	177
		Over 300 HP	-	179
SHOVELS		0.5 to 1.0 cu. yd.	260	261
		1.1 to 1.5 cu. yd.	262	-
		1.6 to 2.0 cu. yd.	264	-
		2.1 to 3.0 cu. yd.	266	-
		Over 3 cu.yd.	268	-
DUMP TRUCKS		To 10 cu. yd.		311
		11 to 15 cu. yd.		313
		16 to 20 cu. yd.		315
				317

Figure 5.1

EQUIPMENT INVENTORY - LOCATOR

SOURCE OR FIRM ____________________ LOCATION SERIAL NO. __________

STREET (OFFICE) ____________________ CITY ____________________

PHONE ____________________ RADIO FREQUENCY ____________________

STREET (STORAGE YARD) ____________________ CITY. ____________________

PHONE ____________________ CONTACT(S) ____________________

Equipment	Type	H.P. Or Cap.		Code	Manufacturer	Model	Con-dition	No
		Value	Unit					

Figure 5.2

The yard equipment locations can be put on to a map as shown on Figure 5.3. This, together with information on Figure 5.2 will be preliminary to the operation of putting the equipment, in the geographic zones, into working groups, which is explained in Section 8. A map similar to Figure 5.3 can be used as a guide in determining most feasible MSA locations for debris removal resources.

At completion of the inventories, a master summary of total equipment resources by code and yard serial number will be made on a table as shown in Figure 5.4. A total for all zones or the geographic areas for the City will be made, Figure 5.5. In pre-event planning this inventory should be updated at least once a year and preferably at six month intervals. During periods of increased readiness, as equipment is moved to MSA's, the inventory sheets will be reworked. After an attack, or other event, and mobilization, these inventories will be adjusted daily to show effects of damage to or isolation of equipment as well as inventory reductions due to assignment of resources to tasks. These daily adjustments will show return of resources to inventory at completion of task.

In the upper part of the equipment inventory sheet (Figure 5.4) is a space for "Zone Situation". This will be filled in only on the zone sheets and only after an attack, or event, except that in a pre-attack planning exercise an assumed value may be inserted. The zone situation is that code for severity of dynamic or fire damage from Figure 4.13. If this rating is 3, 6, 7, 8 or 9 it should be assumed that the resources are not available and those units on that Zone Sheet should be deleted from the total sheet for the whole city. If a field reconnaissance report subsequently indicated that all or part of the resources did survive and were obtainable, then those resources should be reinstated in the summary.

EQUIPMENT YARD LOCATIONS

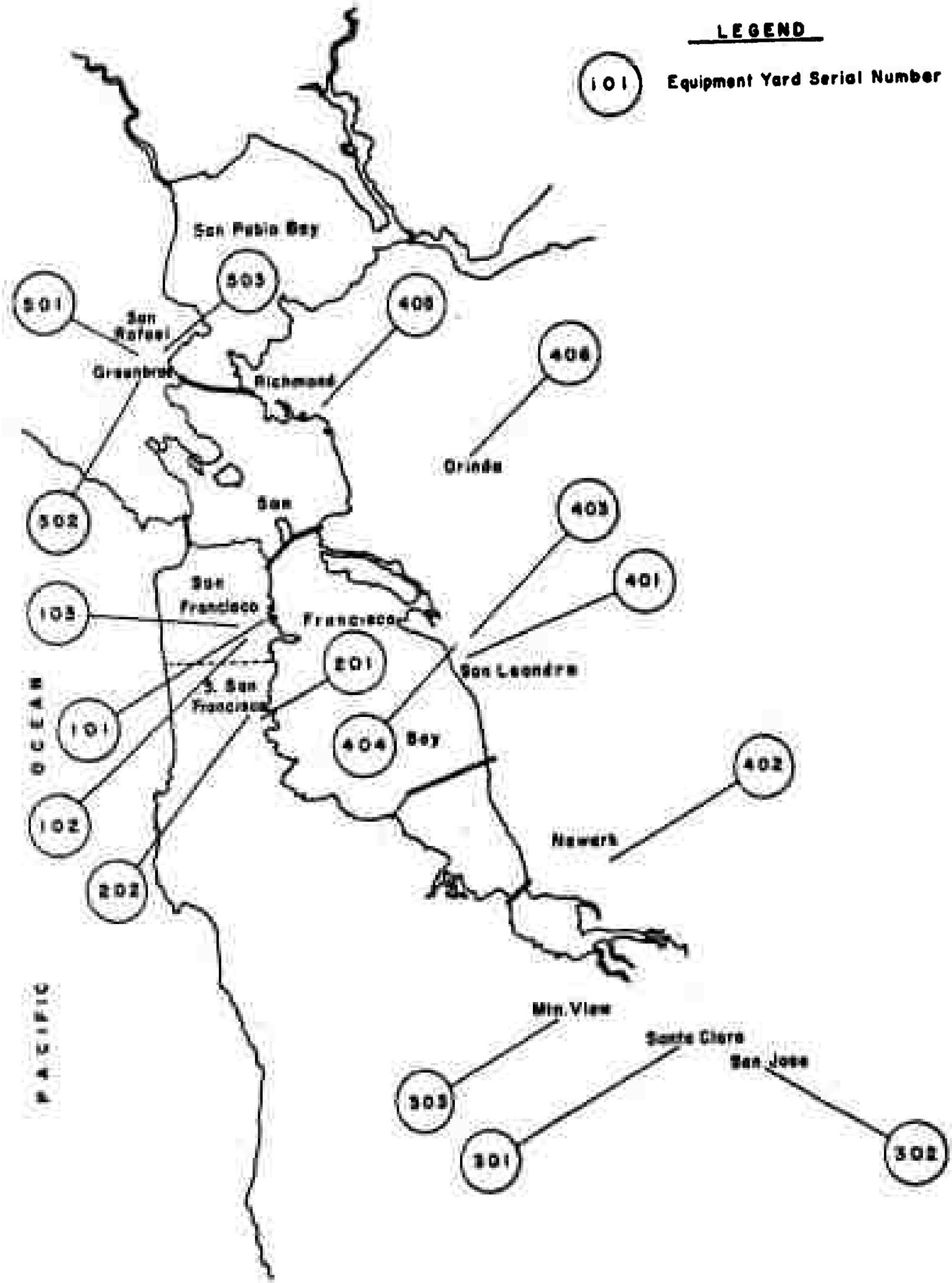


Figure 5.3

KEY EQUIPMENT INVENTORY
ZONE SUMMARY

ZONE NO.__________ SITUATION:__________ DATE__________

QUANTITY

Owner Serial No.	EQUIPMENT CODE											

Figure 5.4

KEY EQUIPMENT INVENTORY SUMMARY

CITY OR AREA: ______________________ DATE ____________

QUANTITY

Zone No.	EQUIPMENT CODE											

Zone No.	EQUIPMENT CODE											

Figure 5.5

As owner serial numbers are assigned, they will be entered on a table showing owner and yard location as can be seen on Figure 5.6.

5.3 PERSONNEL RESOURCES

Basically, personnel resource requirements can be divided into two categories. They are management and operations.

Management category would include supervisory, clerical, communications, public relations, fiscal accounting, inventory control, task evaluation, resource assignment and information gathering and correlation of activities with other groups.

Operations would include field management of tasks and that personnel actually required to get the job done such as task directors, operators, mechanics and labor.

5.3.1 Management

It should be assumed, in pre-attack, or event planning that some governmental management groups will survive and be able to take command. On the other hand, it must be planned for the absence of such control as a result of the event.

The most logical non-governmental sources for administration of a large construction oriented project, such as debris removal, would be the heavy construction or mining industry.

It would be desirable to have on hand a list of key personnel who could be a cadre for implementation of the debris removal program in the event the normal community direction was indisposed. This reserve cadre should be knowledgeable in the field of heavy construction and hopefully would have some pre-event training in what may be required of them. In this kind of situation such people would have knowledge of and access to the availability

SERIAL NUMBER ASSIGNMENTS

CITY:____________________________ ZONE:____________________________

OWNER	YARD LOCATION	SER. NO.

Figure 5.6

of personnel with some experience in this field or the related one of excavation.

It is suggested that a cadre of key management personnel be listed with significant data about them and trained before an event. Perhaps one such person per 200,000 population of an area should be recruited, listed and trained. Sources of volunteers for such training are several. They include:

1. The Contractors Association - The AGC (American General Contractors).
2. The Civil Engineers Professional Society - The ASCE (American Society of Civil Engineers).
3. The Mining Engineers' Professional Society - The AIME (Society of Mining Engineers of the American Society of Mining, Metallurgical and Petroleum Engineers).

Experienced and trained management personnel would be able to recruit and train or direct the necessary subordinate personnel required to get the job done.

A method of listing the cadre of alternates for management is shown on Figure 5.7.

5.3.2 Operations Maintenance and Labor

In an emergency, labor supply is not a real problem. In most cases, there are more volunteers than there are jobs to be done in the unskilled category. Trained and qualified operator personnel could be in short supply in the early stages of mobilization.

Maintenance personnel will be slightly less critical than operator personnel for two reasons. Key operator personnel can perform essential maintenance. No major maintenance is envisioned as any equipment requiring

KEY PERSONNEL (Management)

No.	Name and Affiliation	Business Address	Phone	Home Address	Phone

Figure 5.7

repairs, needing more than a few hours, more than likely will be abandoned.

Owners of equipment and union headquarters will have a list of operating personnel in the area. Again, as in management, it will be desirable to have a source for a cadre of qualified equipment operators and means of contacting them listed prior to the need. This group should be contacted and provided information on the plan in advance of need. The operators provided must be skilled in operation of the three types of major equipment which are most critical, and they are dozers, front-end loaders and shovels. Figure 5.8 provides a means to list the sources or contacts.

5.4 FUEL AND LUBRICANTS

Initial fuel and lubricants may be supplied from the equipment owner or construction company's facilities, but those for continuing operation will come from the normal commercial distribution channels for such products. In an emergency there will be many demands for P.O.L. for operations other than debris removal. P.O.L. supplies will be needed for trucking, heating and transportation among other requirements.

The debris removal operations will not control the total, or perhaps even the majority of the petroleum fuel resources. The debris removers must produce a list of approximate quantitative requirements to establish plans and a suitable priority for the operation's share of this resource.

The equipment owners, who will be involved, will have knowledge of locations and contacts for obtaining delivery of fuel and lubricants, within the constraints established by the situation. The debris removal headquarters should have names and addresses of contacts at major local P.O.L. distribution centers. A form of tabulating storage sources and normal stocks of P.O.L. is shown in Figure 5.9. These locations with an approximate normal storage capacity should be shown on the map overlay for resources.

KEY PERSONNEL (Operators)

No.	Name and Affiliation	Business Address	Phone	Home Address	Phone

Figure 5.8

P.O.L. SOURCES

DATE ______________________ CITY ______________

SUPPLIER NAME AND PHONE NUMBER	STOCK LOCATION STREET AND CITY	ZONE	NORMAL STOCK			
			Diesel	Gaso-line	Lubr. Oils	Grease Lb.

Figure 5.9

5.5 REPAIR PARTS

Repair parts for the key equipment will be a critical resource. Sales and distribution of heavy construction equipment is an orderly and well-controlled business. There usually will be only one dealer for any one make of new equipment in any metropolitan area. For example, there will be only one Allis Chalmers dealer for the whole section of the country in which the affected city lies. Similarly, there will be only one Caterpillar and one International Harvester dealer and one only for each of the other major manufacturers. Each of these may have a branch or other warehouse in another city, which in many cases will be a few hundred miles distant. Such branches may be supplemental sources of parts supplies, as the chances are that a city at such distance would not have a similar debris or damage problem.

The table on Figure 5.10 shows the principal manufacturers of key equipment to be used in debris removal. The local planner should have a list of personnel contacts at: the local distributor; each of the factories; and any other nearby major source of repair parts inventories. The latter may be: zone, branch or district offices of the manufacturer; government installations such as highway maintenance offices; large contractors; quarries; or mines.

Figure 5.11 shows a method for showing details of parts sources for each of the fifteen producers of key equipment items listed on Figure 5.10.

KEY EQUIPMENT MANUFACTURERS

Manufacturer	Dozers	Front End Loaders	Shovels	Graders
Allis Chalmers (AC)	X	X		X
American Hoist and Derrick			X	
Bucyrus Erie (BE)				
Caterpillar (CAT)	X	X		
Eimco	X	X		
Gallion				X
Insley			X	
International Harvester (IH)	X	X		
Koehring			X	
Lima			X	
Marion			X	
Northwest			X	
P & H			X	
General Motors (TEREX)	X	X		X
Trojan		X		X

Figure 5.10

EQUIPMENT PARTS LOCATOR

MANUFACTURER: ______________________ DATE: ______________

EQUIPMENT: ______________________

FACTORY ADDRESS: (MAIN OFFICE)	(BRANCH)
STREET ______________________	______________________
CITY ______________________	______________________
PHONE ________ RADIO ________	______________________
CONTACTS ______________________	

LOCAL DISTRIBUTOR NAME: ______________________

STREET ______________________

CITY ______________________

PHONE ________ RADIO ________

CONTACTS ______________________

NEAREST DISTRIBUTOR ELSEWHERE: NAME: ______________________

STREET ______________________

CITY ______________________

PHONE ________ RADIO ________

CONTACTS

OTHER IMPORTANT PARTS SOURCES:

Figure 5.11

SECTION 6
EVALUATION OF CLEARING TASKS

6.1 INTRODUCTION

Clearing tasks must be described with sufficient and significant data to permit evaluation of the task with respect to both the removal effort required and objective. This will assist in work scheduling and will provide aid to those in authority who will assign final priorities.

The procedure for evaluation must be one that will permit some pre-attack planning or estimating. It must be adaptable to revision after an event a; real results, or conditions, are reported.

The manager of debris clearing will be subordinate and report to the commander of the total emergency operation. In each city this direction and control may be different but for this discussion it will be called the D & C. The manager will look to the D & C for assignment of task priorities. There could be situations where he is out of contact with the D & C and certain guidelines may be helpful for his evaluation of urgency and the initiation of clearing operations. The manager's initial actions may be countermanded after contact is re-established with D & C.

6.2 LISTING OF TASKS

Section 2 of this report shows a means of listing tasks and describing the debris environment.

An analysis of several hypothetical situations indicates that the first debris clearing action after an event, which causes debris in the streets, would be to make a network of cleared routes generally connecting each area of the city where there may be survivors. It is likely that these routes will have been pre-planned. These may be rather long routes and pass or be near

to several kinds of facilities which would be critical to the overall emergency effort. Some of the routes may be divided into several individual tasks depending on type of debris, access or other considerations. The D & C could direct that alternate or lateral routes be cleared from these major routes and assign high priorities to such tasks.

The debris group should provide the D & C as much information as possible on each task and the chance of its successful completion. Those tasks from Figure 2.1 should be listed on a form to display the general purpose or objective of the tasks. This can be done on a form as shown on Figure 6.1. They may be listed sequentially by task number.

Some of the data for completing details of Figure 6.1 can be obtained from the D.P.S. sheets, Figure 4.2. Most of the descriptive information will be based on knowledge of facilities and activities in the areas, some of which is available to the debris manager through surveys made in pre-event planning in preparation of the D.P.S. sheets.

On those tasks, involving long routes, the most critical facility en route will be listed. See Figure 6.2 and subsequent discussion of it in this section. One or two words will describe the facility such as "hospital", "school", etc.

Under "Supplied", a "yes" or "no" should show that the goal does, or does not, have food, water and other essentials to support life.

"The Number of People" column is self-explanatory. In most cases, this will be an estimate of the number of people trapped or in the area, and in need, based on known population of the area or from post-attack reports.

"Condition of People" should be one or two words such as "healthy", "ill", "injured", "incarcerated", "sheltered", "exposed", or other suitable description or descriptions.

TASK EVALUATION

PROVISIONAL PRIORITY

Task No.	Facility	Supplied	Number of People	Condition of People	Location		Task Purpose Code	Provisional Urgency	Chance of Success	Provisional Priority
					Zone No	Restrictive Tasks				

Figure 6.1

TASK CODE

SITUATION	FIRST DIGIT
FIRES	1
HOSPITALS	2
SCHOOLS AND INSTITUTIONS	3
HOMES FOR THE AGED	4
UNSHELTERED GROUPS	5
SHELTERED GROUPS	6
UTILITIES	7
WAREHOUSES OR FACTORIES FOR CRITICAL MATERIALS	8
GOVERNMENT BUILDINGS	9
NUMBER OF PEOPLE	**SECOND DIGIT**
GROUPS OVER 100	1
GROUPS 50 to 100	2
GROUPS 25 to 5	3
GROUPS 10 to 25	4
GROUPS LESS THAN 10	5

Figure 6.2

The "Location" should show the zone number which will have been established for debris clearing purposes. The next column is for "Restrictive Tasks", if any, which must be completed to provide access to the start of task under analysis.

The "Task Purpose Code" might be a two-digit number which will describe the essential purpose of the task. This would be used, primarily, to assist in establishing the urgency. The first number of the two-digit number can be obtained by data on top portion of Figure 6.2, and the second digit obtained from the bottom section of that same figure. For example, a grammar school with 200 students would be coded 31, or "3" for "Schools" and "1" as a second digit for "more than 100". A hospital with 65 patients and staff would be Code 22, etc.

Generally speaking, those tasks with lowest first numbers in the codes will have the highest urgency. Those with identical first numbers normally will be arranged in urgency with the ones having the lowest second number given the higher urgency consideration.

A guide for assigning provisional urgencies from one to ten is as follows. Refer to Figure 6.3. Use the task purpose code to find the job in the first three columns. The indicated provisional urgency shown in the fourth column is put into the "Provisional Urgency" column on Figure 6.1.

Local conditions may dictate a judgement granting a higher urgency which may not correspond with this general procedure.

It should be stressed that these are provisional guidelines to be used only if priorities have not been established by D & C. They must be subject to change. Changes can result from such things as reconnaissance reports showing different debris situations or conditions of people, or new developments such as fires or fallout. They may be influenced as well by subsequent

PROVISIONAL URGENCY & PRIORITY

Task Code			Provisional Urgency	Provisional Priority			
First Digit	Second Digit			Chance of Success			
	Min.	Max.		1	2	3	4
1	1	2	1	1	1	2	4
1	3	4	2	2	2	3	6
1	5	5	3	3	4	4	8
2	1	1	1	1	2	3	5
2	2	3	2	2	3	4	8
2	4	5	3	3	4	4	8
3	1	1	3	3	3	5	6
3	2	4	4	4	4	5	7
3	5	5	5	5	6	7	8
4	1	3	5	5	8	10	16
4	4	5	6	5	8	11	17
5	1	2	6	6	8	11	17
5	3	5	7	7	9	12	18
6	1	3	7	7	9	12	18
6	4	5	8	8	11	14	19
7	1	3	8	8	11	14	19
7	4	5	9	9	12	16	20
8	1	4	9	9	12	16	20
8	5	5	10	10	16	18	20
9	1	5	10	10	18	18	20

Figure 6.3

evaluation of chances of success and this effect is discussed in the following paragraphs.

6.3 CHANCES OF SUCCESS

The chances of successfully completing a task will need to be known by D & C or others who will be establishing priorities. If there appears to be no chance of success, it may be a useless waste of resources to start it, even though it may have a high provisional urgency. On the other hand, a high urgency task with a low chance of success may be given an even higher priority by judgement of D & C, based on need, if such change would improve the overall operation.

If there is an abundance of debris removal resources, the task may be started even though its chance of success appears non-existent. In such an over-abundance, however, urgencies and priorities would mean little except perhaps to establish the order in which tasks would be started.

The chances of success may not be known at the time of assigning the provisional urgency rating. This chance is based on performance estimates for the tasks as described in Section 8 of this report. That section deals with allocation of resources based on availability and productivity.

A chance of success numerical rating is suggested. It is based on calculation of time required to accomplish the task as opposed to the time estimated in which it needs to be accomplished. Again, these data on time requirements, and needs, are used and described in Section 8. The next column of Figure 6.1 is one which shows "Chance of Success". It is noted as a numerical value from 1 to 5 selected from Figure 6.4 which is based on the productivity evaluation described in Section 8. Figure 8.1 shows a time allowed and time required for each task. If the task can be performed within the time specified, it will get top rating of 1. The more time it requires, in

CHANCE OF SUCCESS

TASK TIME SPECIFIED DAYS/HOURS	RATING			
	1	2	3	4
	MINIMUM TIME REQUIRED TO DO JOB - DAYS/HRS			
.5/12	.5/12	.70/17	.80/19	1.0/12
.75/18	.7/18	.9/22	2.2/29	1.5/36
1.0/24	1./24	1.2/29	1.6/38	2.0/48
1.25/30	1.25/30	1.6/38	1.9/46	2.5/60
1.50/36	1.50/36	1.9/46	2.4/58	3.0/72
1.75/42	1.7/42	2.4/58	2.8/67	3.5/84
2.0/48	2.0/48	2.6/62	3.2/76	4.0/96
2.5/60	2.5/60	3.3/79	4.0/96	5.0/120
3.0/72	3.0/72	3.9/94	5.4/120	6./144
4.0/96	4.0/96	5.2/125	6.4/154	8./192
5.0/120	5.0/120	6.5/156	8./192	10/240

Note: If task analysis shows that it cannot be performed with available resources, a chance of success rating of "5" is assigned.

Figure 6.4

relation to specified time, the lower chance of success (higher rating number). If a task is specified to be done in 1.25 days (30 hours) but is estimated to require two days (48 hours), it will get a rating of "3" in chances of success. As noted on Figure 6.4, the task analysis may show that there is absolutely no chance of performing it with available resources. If such is the case, a chance of success rating of "5" will be noted on Figure 6.1 to indicate or flag this condition.

6.4 PROVISIONAL PRIORITIES

Consideration of provisional urgency and chance of success ratings will provide a guide to establish "Provisional Priorities", the last column of Figure 6.1. Figure 6.3 provides a chart to give each task a provisional priority rating of from 1 to 20. Initial assignment of resources could be made on the basis of tasks having the lowest (numerical) provisional priority.

The task code and provisional urgency are identified on the left-hand portion of Figure 6.3. Reading to the right, a provisional priority number is listed under the appropriate chance of success rating column. For example: It is decided that a route to a school with 75 students be cleared in two days. The task code is 32. Analysis has shown that the actual clearing task will require 2.8 days; therefore, the chance of success rating is 2. The provisional priority of this task is 4.

All tasks which have previously been given a chance of success rating of "5" are automatically assigned a provisional priority of 20.

The preceding paragraphs indicate how provisional priorities could be established by evaluating clearing task requirements and objectives. Whether or not such priorities would be used depends on post-attack conditions. As mentioned in paragraph 6.1, the final analysis and the assignment of resources and priorities would be made by D & C. Information provided by task evaluation would be helpful.

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SECTION 7
MOBILIZATION

7.1 INTRODUCTION

Mobilization, or marshalling of resources for debris clearing operations involves many facets. Subjects which must be considered include:

1. Management or control
2. Administrative quarters and communications
3. Staff personnel assembling
4. Construction equipment and areas for its assembly and dispersal
5. Labor access and control
6. Supplies
7. Transportation for personnel, equipment and supplies.

The purpose of this study is to provide guidelines for the actual physical operation of removing debris for the emergency phase. The appointment or organization of staff and methods of getting the operation underway are as important as providing guidelines for the staff to do an effective job.

It is assumed that local conditions, and potential effects of the debris causing event, will dictate requirements and personnel for overall supervision of work performed in accordance with this study. The study will provide the overall authority some aid in selecting managers from those best qualified in the construction or public works fields.

In pre-event planning, the mayor or other authority in the area may appoint a debris removal manager. The manager's planning in advance should provide him with means, during increased readiness to:

1. Establish contact with D & C
2. Establish base of operation

3. Assemble key staff

4. Mobilize resources.

These functions of organizations are essential to provide the initiation of actual debris removal operations and direction for each task to get the job done.

7.2 STAGING AREAS

Normally, one or more multipurpose staging areas (MSA) will have been selected for the disaster relief activity. One might house the overall command and the control headquarters. The debris removal activity may be only one of several management groups in that MSA so that the site selection for some cities may or may not be one at which heavy construction equipment can be assembled and maintained.

In some cases it may not be advisable to assemble large quantities of equipment during the increased readiness period. Although much of the key equipment is rugged and will withstand fairly large overpressures it could be made inoperable by isolation, fallout or fire. Decisions as to use of MSA's for debris removal operations will depend on the Emergency Operating Plan for the area in question.

7.3 ORGANIZATION MOBILIZATION

The debris manager would appoint key personnel using guidelines made on the basis of suggestions of Section 5 of this report during pre-event studies. Many cities, hopefully, will have made these pre-event plans to such a point that mobilization of the key personnel can be accomplished in a few hours.

The operating base for debris removal activities should have at least five large rooms and a small auditorium for briefings. A school or abandoned

office would be ideal. Shopping centers with office complex are good candidates for headquarters sites. The site should have adequate parking space as there will be considerable vehicular traffic in and out of this headquarters.

All band radio and telephone communications must be established early.

Feeding and other facilities for headquarters and transient operator personnel should be provided. Sources of office furniture, typewriters, stationery, drafting boards and filing cabinets should be arranged. During increased readiness (IR) time, these and all pre-event assembled data on debris removal should be moved to the headquarters site.

7.4 EQUIPMENT MOBILIZATION

Equipment mobilization is that part of marshalling of resources which is most important to this study. Primarily, it means preparing and moving the equipment to the task or to the central or subordinate MSA within one of the zones where it may be required.

Most of the equipment considered for this work is comparable in mobility requirements. It takes little or no more time to move a 300 HP tractor on a low boy trailer than it does to move a 150 HP tractor on the same type of equipment for short hauls, as between zones in a city. Self-propelled wheeled vehicles travel at approximately the same rate of speed as truck trailers. An estimate of time required to move equipment from zone to zone or from a near-by mutual aid area to a particular zone can be made as shown on Figure 7.1. It is similar to a mileage map and is referred to as a "Zone to Zone Time Table".

The table has been filled out for a hypothetical situation. It will be noted that there is a column to the left called "Travel to Area". This is a space to put in hours required to get equipment from pre-determined distant

ZONE TO ZONE TIME TABLE

TRAVEL TIME - HOURS

From Zone	Travel to Area	To Zone 1	To Zone 2	To Zone 3	To Zone 4	To Zone 5	To Zone 6	To Zone 7
1			2.0 3.0 5.0	3.0 5.0 7.0	2.0 3.0 6.0	2.0 3.0 4.0	4.0 6.0 8.0	2.0 3.0 5.0
2	4.0	2.0 3.0 5.0		1.5 2.5 4.0	1.0 2.0 3.0	3.0 5.0 6.0	3.0 4.0 5.0	3.0 4.0 6.0
3		3.0 5.0 7.0	1.5 2.5 4.0		1.0 2.0 3.0	4.0 5.0 6.0	1.0 1.5 2.0	2.0 3.0 4.0
4		2.0 3.0 6.0	1.0 2.0 3.0	1.0 2.0 3.0		1.0 1.5 2.0	1.0 1.5 2.0	4.0 5.0 6.0
5	10.0	2.0 3.0 4.0	3.0 5.0 6.0	4.0 5.0 6.0	1.0 1.5 2.0		2.0 3.0 4.0	5.0 6.0 7.0
6	3.0	4.0 6.0 8.0	3.0 4.0 5.0	1.0 1.5 2.0	1.0 1.5 2.0	2.0 3.0 4.0		1.0 2.0 3.0
7	7.0	2.0 3.0 5.0	3.0 4.0 6.0	2.0 3.0 4.0	4.0 5.0 6.0	5.0 6.0 7.0	1.0 2.0 3.0	

Figure 7.1

locations to the MSA or other marshalling yards such as railroad yards or truck terminals in specific zones equipped to receive such shipments. This distant traveling time, when used, naturally must be added to the zone to zone travel times.

Three different "hour" figures are given for travel time between any two zones. This is to indicate possible range of time required due to different debris conditions which may exist along the route. For example: Equipment traveling from Zone 5 to Zone 6 may require from two to four hours depending on restrictions presented by the anticipated debris environment. If the equipment was from a distant area requiring ten hours to get to Zone 5, then the mobilization time would be between 12 and 14 hours. Hours used in preparing such a table should reflect estimates made for the particular study area taking into account actual distances between zones, probable travel routes, etc.

Pre-event inventory of key equipment may indicate that the owner's yard locations are such as to provide reasonable dispersement of equipment throughout the study area. During periods of increased readiness it may be advisable to mobilize equipment at its home base. The equipment could be fueled and made ready for transport to designated MSA's or task assignments as the case may be. As mentioned, this is a decision for local authorities. In the event that equipment was mobilized at its home base, it would be necessary to provide communication facilities and personnel shelters at or near the yard location. In some instances, owners may have existing radio systems which could be used.

7.5 P.O.L. MOBILIZATION

In most cases P.O.L. supplies will be drawn from the regular commercial storage areas for petroleum products. Unfortunately, in most cities these

often are concentrated in one area which may be near a port or rail or pipe line terminal. This makes them rather vulnerable to a disaster centered in that area.

During periods of increased readiness, it would be desirable to arrange for each large user of P.O.L. who has yard storage facilities to stock up to capacity. In this way the P.O.L. resources would be distributed so that it is less vulnerable to complete loss and there are better chances that some supplies will be closer to the task site at which it may be required. Also, it would be desirable to ask for dispersement of any portable diesel fuel tanks to different zones where debris difficulty has been indicated by debris prediction studies. These portable tanks should be filled. Drums of fuel oil should be assembled at each MSA or yard location. They will be useful to stock individual tasks and as a means to haul fuel over debris with a front-end loader.

7.6 MAINTENANCE MOBILIZATION

Mechanics' tools and welders should be assembled during increased readiness. It is best not to try and stock additional repair parts but to depend on drawing those parts from the dealers or major users as needed.

7.7 MISCELLANEOUS SUPPLIES

An assortment of hard hats, safety shoes, rubber coats and boots, picks, shovels, etc. should be stocked at the different locations during increased readiness periods. Many of these miscellaneous supplies will be available from those contractors who are furnishing the major equipment.

7.8 TRANSPORTATION MOBILIZATION

During increased readiness all commercial haulers of heavy equipment should be asked to move their low boy trailers and tractors to MSA's

or yards which will be the main source of equipment. Pickup trucks and four-wheel drive vehicles should be fueled and available.

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SECTION 8
ASSIGNMENT OF RESOURCES

8.1 INTRODUCTION

Resources must be assigned for efficient completion of the tasks. The assignment must be as orderly as possible under rather extraordinary circumstances. Priorities must be followed.

Records must be kept of remaining available resources including manpower and material at all stages of the mobilization and activation.

The preceding sections of this report provide task definition and resource inventory and mobilization guides.

This section describes how task requirements can be matched with those resources, particularly the very critical equipment resources.

8.2 TASK REQUIREMENTS

A form, as shown as Figure 8.1, should be prepared for each task. This task requirement card serves three purposes. Its primary purpose is to assist in selecting the best available resource. Its other purpose is to show resources assigned and their total requirements for completing the task.

The top part of Form 8.1 describes the task purpose, conditions, locations, and time requirements. Most of the data for this part of the form can be read directly from Figures 1.2, 2.1 and 6.1. The date is that on which the form is being filed. Form 6.1 provides: task starting point, zone or street location, priority and urgency. Figure 2.1 provides: task no., operation type; allowed time - hours; debris type; traffic content; average depth in feet; length of route in thousands of feet; and debris volume in units of volume of 1,000 cu.yds.

Finish day and hour is computed by adding the time allowed in which

TASK REQUIREMENT CARD

Task Requirement Summary

Zone Situation: ________ Fall Out:___________ Fire Condition:___________

Task No:_________Zone:_______ Date:___________Priority:________________

Route Width:________Street Width:________Average Depth:_____ Length: ________

Operation Type:_____Time Allowed-Hrs:______Finish Day:_______Hr:___________

Debris Type:_______Variable Cont:________Adjusted Debris Type:______________

Volume: ______________________Req.Prod:________________________________

Resource Evaluation

Group		Production Cu.Yd./Hr.				Time - Hours		
No.	Zone	Standard Prod.	Factors		Adjusted	Mobil.	Oper.	Total
			Comp.	Units				

Supporting Resources

Code	Quantity
620	
621	
622	

Resource Assignment:

Group No. ________

Start Day________________________Hour_______________________________

Finish Day______________________Hour___________Gross Oper.Time _____

Labor Hrs.by skill: 1 ______2_________3___________4____________________

Labor Total Hrs:____

Dies.(gal):____________Gas(gal)______________Lube(lb.)__________Oil (gal.)___

Figure 8.1

job must be done to that time (day and hour) at which form is being computed.

The adjusted debris type can be read from Figure 1.2, using debris type and traffic content.

The approximate net production rate required is the debris volume, in cubic yards, divided by the allowed time in hours. This will be a much lower rate than will be needed for equipment capacity as there will be lost time in mobilization and elsewhere. This is detailed below.

8.3 RESOURCE EVALUATION

The most critical resource will be key or major equipment. Personnel and P.O.L. supplies are more mobile and, therefore, can be obtained from greater distances in the time likely to be available.

The center section of Form 8.1 provides a means to evaluate equipment groups with respect to task requirements.

8.3.1 Resource Grouping

Equipment resources will have been inventoried as has been described in Section 5. See Figures 5.2, 5.3, 5.4 and 5.5.

Construction equipment must be put into groups for effective operation. A group may be simply one bulldozer and a few hand tools. It may be a more complex group of several bulldozers or combinations of shovels and front-end loaders and/or bulldozers. All groups that include shovels and most that include front-end loaders will have trucks. They will require part-time allocation of fuel trucks or other service vehicles. Nearly all groups for debris removal will be fairly small. This is because tasks, as envisioned, will have limited working space.

The equipment group concept for this work was introduced in Section 3.2 of Reference 1 and illustrated in detail in Appendix B of that report.

Figure 8.2 shows a group card form for listing equipment and other resources for each equipment group formed. Provisional equipment groups should be made on such forms for all of the equipment inventoried as described in Section 5. These provisional groups can be dissolved and other groups made with the equipment either prior to assignment (for special task needs) or on completion of a task. The group will be dissolved if the equipment is taken out of service for any reason.

The group card shown on Figure 8.2 differs from that described in Reference 1 in a few details. These provisional groups should be made using judgement by persons with experience in earth excavation by construction machinery and a general knowledge of the probable nature of the tasks likely to be required.

Group numbers will be assigned sequentially to the groups as group cards are filled in.

The "Date Formed" is the date the group card is filled out. The "Date Dissolved" is the date the group is dissolved which may be for, among other reasons, the following:

1. Equipment is used in forming another group.
2. Equipment is damaged beyond repair.
3. The group is modified for a task by additions or deletions.

The left-hand column of the main body of the group form is for listing major and minor equipment and supporting resources usually by code. After the code number for the major equipment, there will be a slant line and the equipment's location or yard serial number will follow the slant line.

The "No. Reqd." (number required) column is the number of the specific pieces or units of resources listed in the left-hand column of the group card.

GROUP CARD

GROUP:__________ ZONE:__________ DATE FORMED:________ DATE DISSOLVED:________

RESOURCE-CODE/LOCATION	No. Req.	REQUIREMENTS FOR ONE HOUR GROUP OPERATION									
		LABOR: MANHOUR - SKILL						FUEL			
		Operating		Maintenance		Other		Diesel Gal.	Gasoline Gal.	Lube Lb.	Oil Gal.
		M.H.	Skill	M.H.	Skill	M.H.	Skill				
Major Equipment											
Minor Equipment											
Other Labor											
Hourly Requirements											

STANDARD PRODUCTION - CU.YD./HR.: ________ TYPE OF OPERATION:____________

Figure 8.2

The labor table part of Figure 8.2 provides space for listing three categories of labor by skill code and the manhours, per hour of group operation, required for each. Labor Code 1 is equipment operators; Code 2 is mechanics or other skilled; Code 3 is drivers or semi-skilled, and Code 4 is unskilled. The last four columns are for petroleum, oil and lubricant (P.O.L.) requirements and show them by gallons or pounds per hour for each unit in the group requiring such supplies. Figure 8.3 gives data necessary to complete the group card. It shows hourly labor and supply requirements for each type of equipment shown by name and code as well as data on key specifications such as weight, horsepower and capacity where appropriate. Figure 8.3 also shows "standard production" and "type of operation" to which each kind of equipment may be assigned either alone or in multiple units or combined.

Total hourly requirements for all resources in the group are summarized on the appropriate line of Figure 8.2. Standard production for the group, as well as type of operation will depend on type and number of major equipment used in forming the group.

Transportation requirements are not shown on the group card as analysis has shown that all of this equipment can be transported by truck, tractor and low boy trailers or are self-propelled. Rail haulage would seldom be used except for equipment from great distances. The latter, if required, more than likely would be supplementary to the local inventory and in most cases called in only if required after an event. An exception to the post-event plan for any required rail transport, would be in what appears to be an unlikely discovery in pre-event inventory that there will be a shortage of equipment in the city or study area. In such a case distant sources which may be less vulnerable to damage may be established. Arrangement then

EQUIPMENT SUPPLY REQUIREMENTS AND PERTINENT SPECIFICATIONS

EQUIPMENT CODE & SPECS.								P.O.L. REQ./HR.				LABOR/HR.				SUPPORT EQUIPMENT REQUIRED		OPERATION TYPES APPLICABLE		
			CAPACITY									GRADE								
TYPE	MOUNT	CODE	QTY.	UNIT	AVE. HP	AVE. WT. TONS	STAND. PROD. CU YD /HR.	GAS. GAL.	DIES. GAL.	LUBE. LB.	OIL GAL.	1	2	3	4	CODE	QTY.	SINGLES	MULTIPLE	COMB.
Dozers	Crawler	280	-	-	124	14	140	-	5.0	.4	.14	1	.20	-	-	-	-	1-4-7	4-7	2-5-8
		282	-	-	170	23	230	-	8.0	.4	.17	1	.25	-	-	-	-	1-4-7	4-7	5-8
		284	-	-	227	28	330	-	11.3	.5	.24	1	.30	-	-	-	-	4-7	7	8
		286	-	-	270	29	400	-	14.1	.7	.27	1	.33	-	-	-	-	4-7	7	8
		288	-	-	350	38	520	-	16.6	.8	.40	1	.41	-	-	-	-	7	-	8
	Wheel	283	-	-	170	18	190	-	7.5	.3	.17	1	.23	-	-	-	-	1-4-7	4-7	2-5-8
		285	-	-	219	24	275	-	10.0	.4	.20	1	.25	-	-	-	-	4-7	4-7	5-8
		287	-	-	303	32	350	-	13.7	.7	.30	1	.35	-	-	-	-	4-7	7	8
		289	-	-	435	46	530	-	17.5	.7	.44	1	.47	-	-	-	-	7	-	8
Front End Loaders	End Dump Crawler	160	2.0	cu.yd.	112	13	100	-	5.0	.5	.11	1	.22	-	-	311	2	1-3-6-9	4-9	2-5-8
		162	2.5	cu.yd.	164	20	140	-	7.5	.6	.16	1	.31	-	-	313	2	4-3-6-9	4-9	5-8
		164	3.0	cu.yd.	218	28	185	-	10.0	.7	.21	1	.35	-	-	313	2	4-6-9	7	8
		166	4.0	cu.yd.	254	37	245	-	11.5	.9	.25	1	.37	-	-	315	2	7-6-9	7	8
	End Dump Wheel	161	2.0	cu.yd.	123	10	130	-	5.6	.3	.13	1	.24	-	-	311	2	1-3-6-9	4-6-9	2-5-6
		163	3.5	cu.yd.	181	16	185	-	8.1	.6	.17	1	.40	-	-	313	2	1-3-6-9	4-9	2-5-8
		165	4.5	cu.yd.	230	20	250	-	10.5	.7	.22	1	.37	-	-	315	2	4-3-6-9	4-7-9	5-8
		167	5.0	cu.yd.	296	29	330	-	13.5	.8	.30	1	.42	-	-	315	2	4-6-9	7-9	8
		169	5.5	cu.yd.	340	30	430	-	15.1	.8	.35	1	.46	-	-	315	3	7-6-9	7	8
	Side Dump Crawler	170	1.75	cu.yd.	115	16	125	-	5.0	.5	.11	1	.24	-	-	311	2	1-3-6-9	4-6-9	2-5-8
		172	2.5	cu.yd.	170	22	190	-	7.5	.7	.17	1	.34	-	-	311	2	4-3-6-9	4-9	5-8
		174	3.0	cu.yd.	218	28	215	-	10.0	.7	.21	1	.36	-	-	313	2	4-6-9	7-9	8
		176	4.0	cu.yd.	254	37	290	-	11.5	.9	.25	1	.40	-	-	315	2	7-6-9	7	8
	Side Dump Wheel	171	2.25	cu.yd.	115	12	155	-	5.2	.4	.11	1	.26	-	-	311	2	1-3-6-9	4-6-9	2-5-8
		173	3.5	cu.yd.	175	16	220	-	8.0	.6	.17	1	.40	-	-	313	2	1-3-6-9	4-6-9	2-5-8
		175	4.5	cu.yd.	230	21	300	-	10.7	.7	.22	1	.39	-	-	315	2	4-3-6-9	4-9	5-8
		177	5.5	cu.yd.	300	33	400	-	13.7	.8	.31	1	.45	-	-	315	2	4-6-9	7-9	8
		179	5.0	cu.yd.	318	25	525	-	14.5	.8	.33	1	.47	-	-	315	2	7-6-9	7	8
Gdrs	Wheel	141	-	-	128	12	160	-	5.8	.3	.13	1	.23	-	-	-	-	-	-	-
		143	-	-	172	15	200	-	7.3	.3	.17	1	.25	-	-	-	-	-	-	-
		145	-	-	227	22	280	-	10.0	.4	.22	1	.28	-	-	-	-	-	-	-
Shovel	Crawler	260	.75	cu.yd.	82	23	80	-	3.7	.8	.08	1	.29	-	-	311	2	3-6-9	9	2-5-8
		262	1.5	cu.yd.	148	49	160	-	7.0	1.0	.15	1	.32	-	-	311	2	6-9	-	2-5-8
		264	2.0	cu.yd.	210	75	220	-	9.5	1.2	.20	1	.38	-	-	313	2	6-9	-	5-8
		266	2.5	cu.yd.	220	85	260	-	10.3	1.5	.20	1	.45	-	-	313	2	8-9	-	5-8
		268	3.5	cu.yd.	238	86	320	-	10.8	1.8	.23	1	.60	-	-	315	2	8-9	-	8
	W	261	.75	cu.yd.	75	30	80	3.0	4.0	.8	.20	1	.30	-	-	311	2	3-6-9	9	2-5-8
Cranes	Craw.	070	10	tons	90	22	-	-	4.0	.7	.09	1	.32	-	-	-	-	May be used in all tasks.		
		072	20	tons	90	24	-	-	6.0	.8	.10	1	.38	-	-	-	-			
		074	35	tons	140	42	-	-	9.0	1.1	.14	1	.52	-	-	-	-			
	Wheel	071	9	tons	178	12	-	-	6.5	.5	.18	1	.33	-	-	-	-			
		073	16	tons	77	19	-	8.0	-	.3	.10	1	.35	1	-	-	-			
		075	33	tons	92	38	-	8.0	3.1	.9	.20	1	.50	1	-	-	-			
Trucks	Wheel	311	10	cu.yd.	-	-	-	5.0	-	.10	.03	-	.15	1	-	-	-	To be used in all 2, 3, 5, 6, 8 and 9 types.		
		313	15	cu.yd.	-	-	-	-	6.0	.12	.04	-	.18	1	-	-	-			
		315	20	cu.yd.	-	-	-	-	7.0	.14	.05	-	.20	1	-	-	-			
		317	31	tons	213	41	-	4.5	4.5	.35	.21	-	.16	1	-	-	-			
Note 1		751	-	-	-	-	-	2.0	-	.04	.02	-	.10	1	-	-	-	May be used in all tasks.		
Note 2		753	-	-	-	-	-	2.0	-	.04	.02	-	.10	1	-	-	-			
Note 3		755	-	-	-	-	-	2.0	-	.06	.03	-	.10	1	-	-	-			
Note 4		757	-	-	-	-	-	2.0	2.0	.15	.08	-	.15	1	-	-	-			
Note 5		600	-	-	-	-	-	-	3.0	.20	.07	-	-	-	-	-	-			
Note 6		602	-	-	-	-	-	0.8	-	.01	.01	-	-	-	-	-	-			
Note 7		620	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	See Figure 8.4 for use.		
Note 8		621	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-			
Note 9		622	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-			

Notes

1 - Service Truck
2 - Tire Truck
3 - P.O.L. Truck
4 - Sweeper
5 - Air Compressor & Tools
6 - Light Plant & Accessories
7 - Safety Clothes & Small Tools (Fig. 3.5)
8 - Metal Cutting Equipment (Fig. 3.5)
9 - Wood Saws and Tools (Fig. 3.5)

Abbreviations

(1) Gdrs = Graders
(2) Craw. = Crawler
(3) W = Wheeled

Figure 8.3

may be made to get the equipment on board trains and en route to the city during periods of increased readiness. Barges may be needed in a city which depends on bridges for access or one which may be bisected by one or more rivers or waterways. Wheeled units can and probably will travel to tasks within about 30 miles (in an emergency situation) without haulage units. Wheeled units are those with odd or uneven code numbers. Crawler units (even code numbers) in an emergency could travel about 3 miles on city streets to a task on their own power. As a general rule, equipment traveling under its own power (on short hauls) will make the trip in 60% of the time required to get a trailer to haul it.

8.3.2 Resource Evaluation

As was described the above trial groups of equipment should be formed on paper for each zone as soon as the area equipment inventory is completed. Then a group inventory showing zone, group number, operation type, standard production and owner serial number should be made for the complete city or area. See Figure 8.4.

When the group inventory lists are accomplished, the analysis in resource evaluation in the center section of form Figure 8.1 can proceed. The "Operation Type" for the task will indicate that basically, it is either a dozer job, a shovel job, or a combination (of dozers and shovels) job. The "Required Production" will indicate the production rate, but it must be remembered that groups chosen for evaluation usually should have a standard production of at least double this required production. Rather drastic downward adjustments to standard production are required for various practical reasons as are explained elsewhere in this report.

The group inventory lists for the zone involved and its adjoining zones will be searched for groups available which could do the job and which have

ZONE RESOURCE
GROUP INVENTORY

Zone	Group No.	Date Start	Date Stop	Operation Type	Standard Product. Cy/Hr.	Owner or Yard Serial #

Figure 8.4

several times the indicated required production capacity. The most convenient ones geographically will be listed in the first two vertical columns of the center table of Figure 8.1 and their standard production will be put into the third column.

The "composite adjustment" factor will be chosen from Figure 3.3 depending on major equipment, debris type and traffic content. The "units" (or multiple units) factor is selected from Figure 3.4 using number and types of major units from the equipment group card (Figure 8.2) and route width from data at top of Figure 8.1. Standard production for each group listed is multiplied by both factors to achieve adjusted production figure. (Section 11 gives additional details on this procedure.)

The time in hours required to move the equipment to start of task is selected from a table similar to Figure 7.1 and inserted in the mobilization time column. To use Figure 7.1 the zone to start the task is obtained from the top of 8.1 and the zone from which equipment must be moved is from the center table of that figure.

The adjusted production "rate" is divided into the "Volume" number (cubic yards to be moved) from top of Figure 8.1 to arrive at "Operating Time Hours" for the central table of that figure.

"Mobilization Time" and "Operating Time" are added and their sum is "Total Time". The group with least hours in total time probably will be assigned.

In evaluating task requirements, it may be found that a group needs additional supporting resources such as labor, cutting torches, chain saws, protective clothing, etc. A crane may be required in areas of heavy debris with considerable "steel" content. These resources can be added to a group by the person making the analysis on Figure 8.1. His decision will be based

GROUP SUPPORTING RESOURCE SETS REQUIRED FOR VARYING DEBRIS CONDITIONS

One 620 supporting resource set
required per 6 men

Number of 621 sets required.

Original or Adjusted Debris Struct. Content	Average Depth					
	Up to 2'	4'	6'	8'	10'	12'
- 3	1	1	2	2	3	3
- 4	2	2	3	3	4	4
- 5	2	3	3	4	4	5

Number of 622 sets required

Original Debris Structural Content. *	Average Depth		
	Up to 2'	4'	6'
- 2	1	1	2

* Structural Content is from Parameter A-2 of Debris Classification - See 1.2.

Figure 8.5

on debris type and other task requirements. These resources and needs are discussed in Reference 1 and can be selected from bottom portion of Figure 8.3. Figure 8.5 is a guide as to quantity of such resources required for various debris environments. Any additional resource required to augment an assigned group are noted on the bottom center table of Figure 8.1.

8.4 RESOURCE ASSIGNMENT

The assigned group's serial number is inserted in the "group number" slot on the lower part of Figure 8.1. To the start time or hour of assignment the total hours are added to compute finishing day and hour.

The selected group card will be attached to the task requirement card and it will be removed from inventory of remaining resources which are shown on Figure 8.4 for groups and Figure 5.4 for equipment.

Gross operation time must be computed. It is the time for which resources must be provided to complete the task. It has been assumed that requirements for operators, fuel, etc. needed for mobilization will be approximately 60% of similar requirements during actual operations. Therefore, gross operation time = 0.6 x Mob. Time, plus 100% of Operating Time. "Gross Operation Time" is then multiplied by labor summaries for each of the four classes and put in the appropriate slots at the bottom of Figure 8.1. The total of the four is put in the total labor spot for the task on the bottom of that figure. Similarly, P.O.L. requirement summaries from the group card are multiplied by "Gross Operation Time" to give data for the bottom line of each task requirement card. Total required hours for individual pieces of equipment is obtained by multiplying gross operating time by number of units used.

As will be explained, these task resource totals will be used later to make an estimate of total requirements for the complete operation or the total effort as discussed in the next section.

SECTION 9
DETERMINATION OF TOTAL EFFORT

9.1 INTRODUCTION

The ultimate objective in debris removal planning is to provide an orderly means to tabulate and evaluate a variety of potential debris situations and estimate the total resources required for designated clearing operations. Many of the procedures required in pre-event planning, increased readiness alert time and in post-event implementation which give data to this summary of total effort have been described in previous sections.

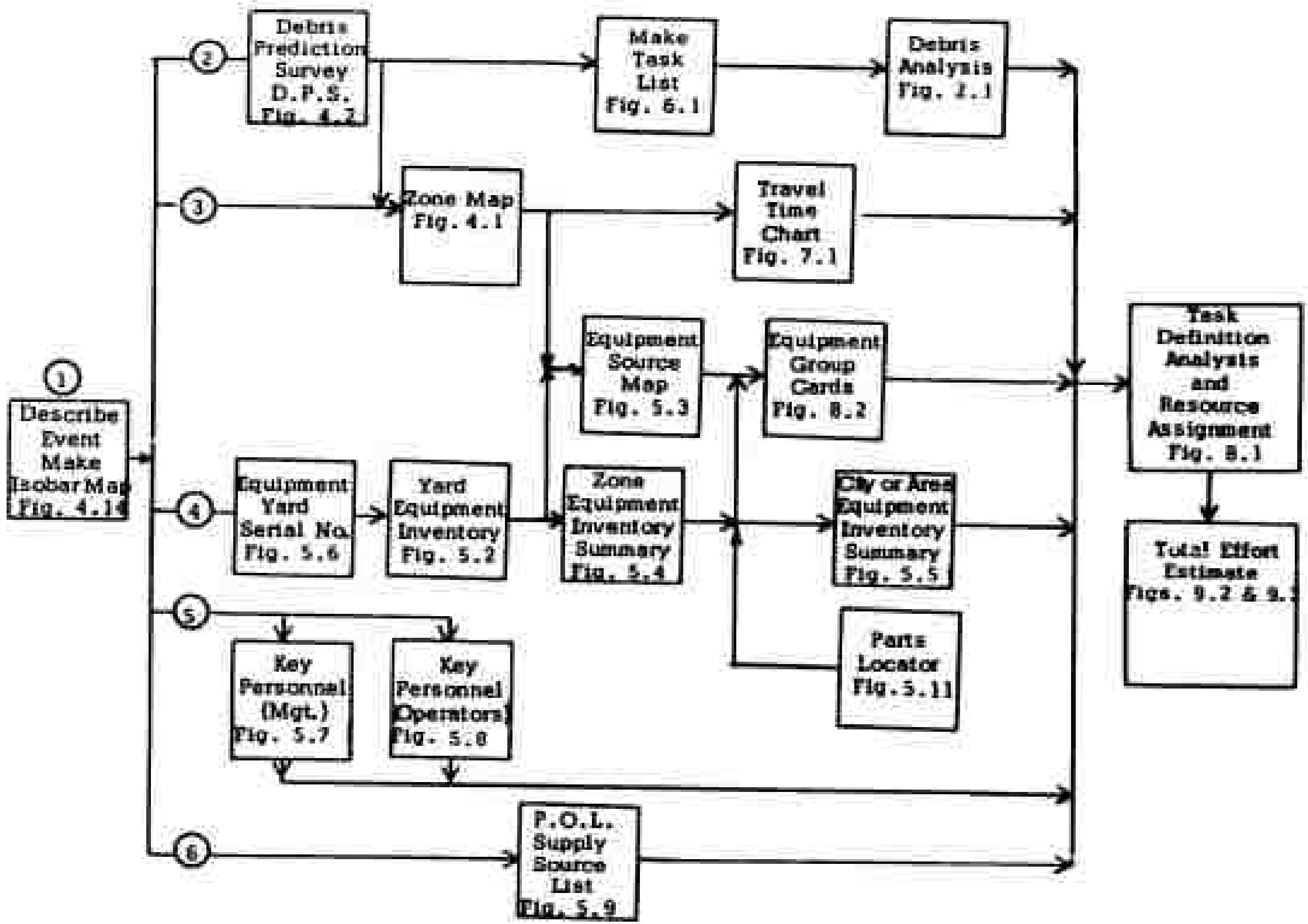
As much of the statistical work as possible should be done in the planning period. These plans are provided to contain essential data in a flexible format adjustable to many possible different situations.

Many of the steps in organization, mobilization and execution can be done concurrently. Some must be done sequentially.

This section of the report describes an orderly process for scheduling the various steps so that debris clearing operations can be set in motion in either the increased readiness or post-attack periods. It provides a means by which an estimate of total effort can be made for different attack conditions and debris clearing requirements.

9.2 SCHEDULING

Preparation for debris removal analysis can be considered by six basic steps. They are illustrated graphically in Figure 9.1. The number at the bottom of each block of the diagram gives the figure number (of this report) which provides the form to be considered. It is assumed that all planning procedures have been completed and are available. The six operations, or steps, are:



STEPS TO ACHIEVE ESTIMATE OF TOTAL EFFORT

Fig. 9.1

1. Event Description
2. Debris Analysis
3. Clearing Requirements
4. Equipment Analysis
5. Personnel Summary
6. P.O.L. Supplies

These all provide information for the final analysis of each task, including task definition, resource evaluation and resource allocation.

The summary of the resources allocated for all tasks provide a total job effort estimate. During actual operation, this must be updated frequently with progress and change of condition reports. The total effort can, therefore, be estimated before an event and during the clearing operation.

The complete process involves assuming a variety of situations before an event, or having reports of the actual situation after an event.

Naturally, results vary with cities and even with zones within any city. A hypothetical situation will be assumed to illustrate the methods proposed. For the purpose of this illustration, let it be assumed that the authorities of San Francisco are estimating clearing requirements necessitated by a nuclear air blast over City Hall.

The first step (Figure 9.1) would be to estimate the isobars of incident overpressure generated by the detonation. These can be plotted on a map of the City and roughly are concentric circles of decreasing pressure from the ground zero. Another source of information for step 1 would be reports of actual damage provided after an event. In pre-event preparation, a survey team has investigated each section or zone of San Francisco with "Debris Prediction Survey" (D.P.S.) forms (Figure 4.2). Data on these forms will provide guidelines for reasonable debris predictions, and

information needed for steps 2 and 3.

Clearing requirements (step 3) can be indicated by the various routes to be cleared and shown on the area zone map. These routes may have been pre-determined or could be designated by D & C in the early post-attack period.

Step 4, equipment inventories and grouping, can start at any time, even before the D.P.S. is conducted. Parts of the equipment analysis, in the final stages, are dependent on knowing zone boundaries which are dependent on the D.P.S.

Steps 5 and 6 are listing of personnel and P.O.L. supplies, respectively. These are highly mobile resources, not influenced so much by location as is equipment. The first parts of studies for 5 and 6 can be conducted concurrently with, and independently from, debris and equipment analysis and area mapping. In an emergency, this concurrent analysis would be the case but in pre-attack planning, these independent functions can be scheduled at the convenience of the planners.

9.3 TOTAL RESOURCE REQUIREMENTS FORECAST

Data and information provided by the completion of the six steps can be summarized on forms as shown in Figure 8.1. It gives the debris environment, task definition, available resource capability and allocation for each task. All resource requirements, other than equipment, can be totalled for each task or zone and then the zones summed for the city on forms as shown on Figure 9.2. Figure 9.3 is used to summarize total equipment requirements, in machine hours, as indicated by data and task analysis given on Figure 8.1.

Both Figures 9.2 and 9.3 are set up for tabulation for either zones or the entire area. The totals at the bottom will provide such things as fuel, manpower, lubricants and machine hours, by major code or type. Thus,

TOTAL RESOURCE NEEDS FORECAST

DATE:______________

CITY:______________________________ AREA______________________________

Task	Equip. Group	Debris Volume (cu.yds)	Labor Hours by skill				POL Total			
			1	2	3	4	Dies Gal.	Gas Gal.	Lube Lb.	Oil Gal.
Total										

Fig.9.2

EQUIPMENT RESOURCE
TOTAL MACHINE HOUR FORECAST

DATE: ______________

ZONE OR TOTAL: ______________

Task or Zone	Equipment Code															
TOTAL																

Fig. 9.3

a measure of the total effort forecast can be made.

9.3.1 During the planning period, it would be desirable to determine total effort requirements for several simulated attack conditions and corresponding debris clearing requirements. Such studies would indicate potential recovery capability based on available resources of the area. Also, it would be a guide as to need and use of mutual aid between areas with respect to debris clearing operations.

9.3.2 The same general procedure of determining total effort can be followed in the post-attack period. In this instance, however, it will be necessary to maintain current records of resource needs and use as the various tasks are undertaken or completed. These reports would reflect actual requirements as opposed to original estimates made on the basis of planning data. This can be accomplished by use of daily progress reports as shown on Figure 9.4. These reports will provide a means of summarizing total resource requirements both during and at completion of a task. All steps previously discussed will be updated with field reports of actual conditions.

In some situations it may be decided locally that these progress reports will be made on a more or less frequent basis than daily. They should be filled out by the manager of each task. Comments noted at the bottom of the form will include such things as:

1. Weather
2. Unusual inclusions or debris characteristics
3. Radiation
4. Incidental rescues
5. Unpredicted damage

DAILY REPORT

Task	Date	Zone	Route Width	Equip. Group		Total Labor	
				No.	Code	Today	To Date

Progress	Original	Today	To Date	Balance
Route Length - Ft.				
Debris Volume - Cu.Yd.				

Labor Used	Class			
Name	1	2	3	4
Tot. Labor by Class Today				
Tot. Labor by Class To Date				

Major Equipment			
Equip. Code	Owner Ser. No.	Hours	
		Today	To Date
Total			

P.O.L. Used	Today	To Date
Diesel - Gal. Gasoline - Gal. Oil - Gal. Lubricants - Lb.		

Other Supplies

Comments:

Signature: ______________________

Task Mgr. (Print): ______________________

Figure 9.4

The data from the daily progress report could be inserted on the task forms of Figure 8.1 and new and current summaries provided for Figures 9.2 and 9.3 showing totals to date or estimate of remaining resource requirements. The progress reports also provide data which may assist in reimbursing those who must be paid for services.

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SECTION 10
SAN FRANCISCO STUDY
DEBRIS ENVIRONMENTS

10.1 INTRODUCTION

Phase III of the research study was to apply and test the proposed debris clearing operational plan with respect to requirements and conditions of a specific area. The City of San Francisco was designated for this purpose. Also, the assignment included the correlation of clearing operations with other Civil Defense functions which might be undertaken in the study area.

The City of San Francisco has adopted an Emergency Operations Plan which sets forth various procedures and plans to be implemented in the event of a nuclear attack or other major disaster. It details the overall organizational control and specific functions to be performed by different city departments and other agencies, utilities, etc. which would be involved in emergency action. The plan considers various stages of readiness or warning which might be applicable to a specific event.

Debris clearing operations are designated as a function or section of the Engineering Annex of that plan. The chief of this annex is the Director of Public Works, who supervises four Coordinators of Engineering Services and thirteen Section Leaders. As used hereinafter in this report, reference to debris clearing "manager" will imply the Coordinator of Street Use, in line with the above. It is assumed that the planning and implementation of debris clearing operations is the primary function of this emergency section.

The Emergency Operations Plan is oriented to nine basic operating situations which relate fire and fallout conditions as described in "Concept of Operations Under Nuclear Attacks" - OCD November, 1967 (Reference 5). This same general concept is followed in the subsequent discussion of debris

clearing operations with the exception that zone situations, which relate blast damage and fire damage, are used instead of the nine basic operating situations. Although debris environments are directly dependent on blast and fire damage, it is realized that any emergency function in the wake of a nuclear attack must consider existing fallout and fire conditions. It is unlikely that a clearing task would be initiated in an area of severe fallout, even though resources were available to do so. This same reasoning applies also to areas with an uncontrollable fire situation. In essence, existing fallout and fire conditions are restraints to clearing operations and are treated as such in the following discussion. They are considered by use of a color code symbol on each task requirement card. This procedure is used primarily to indicate how clearing tasks can be correlated with other emergency functions or plans. (See paragraph 10.9.) The scope of this study does not include determination of time lags or other restrictions which might be imposed on clearing operations due to either fallout or fire conditions. Consequently, only general allowances are made in the following case study.

This section deals primarily with the determination of debris environments and requirements of clearing tasks that may be undertaken in the post-attack period. Section 11 describes resource allocation and total effort.

10.2 ATTACK CONDITION

Although the proposed debris clearing operational plan is adaptable to all simulated or actual attack conditions, most of the data and procedures hereinafter discussed are based on one specific situation--a 1-Mt air burst over City Hall. This attack is the same as considered in Reference 6, which describes it as "sufficient to essentially destroy the city, considering the location of various types of structure". By using the same attack condition, it was possible to compare debris environments (quantities) as predicted in

Reference 6; Figure A-4 through A-12, with those determined by D.P.S. method proposed in this study.

Isobars of incident overpressures, and assumed fire spread of the simulated attack are indicated on the various overlays and maps which are discussed later.

In evaluating the overall debris clearing problem, the following assumptions were made:

1. All elevated freeway structures which were subjected to incident overpressures in excess of 12-15 psi were considered as being destroyed.
2. The San Francisco - Oakland Bay Bridge was not usable.
3. The Golden Gate Bridge was usable.

Sufficient detail is given in the problem study to illustrate how the proposed plan and data could be expanded to cover all possible attack conditions.

10.3 CLEARING ROUTES

Possible methods of defining objectives of clearing operations and establishing priorities are discussed in Section 6. It is obvious, however, that ultimate objectives cannot be determined until after actual attack conditions are known. In general, it can be assumed that major thoroughfares will be cleared for evacuation or access purposes. Routes to essential facilities, major shelters and operational control centers will be cleared as soon as possible. With this in mind, the following clearing routes were established which would probably be typical of an actual situation:

A. Evacuation and general access - 50' path

   1. Third Street Route - Meade Avenue to Kearney and Pacific. This is the

same route as studied in Reference 6.

2. Center of downtown to Golden Gate Bridge via Sansome and Bay Streets.

3. 19th Avenue - Presidio to Southern City limits.

4. From 3rd Street Route to San Francisco Naval Shipyard.

B. Access to facilities - 30' path

5. Van Ness Avenue from Bay Street to City Hall.

6. Geary Street - Van Ness Avenue to 19th.

7. From 19th and Judah to Geary Street via Masonic.

8. Southern portion of City to downtown via O'Shaughnessy Boulevard and Market Street.

9. From Bosworth Avenue to center of town via Mission Street.

10. From 3rd Street to Hall of Justice via 7th Street.

C. Emergency rescue - 20' path

11. From Clayton and Parnassus to Twin Peaks Avenue.

12. Mission to S.F. General Hospital via 23rd Street.

These clearing routes are shown on Figure 10.1. Each route has been divided into inidividual tasks and noted as 1a, 1b, etc. Each task reflecting a different debris environment as determined for individual zones through which the route passes. (See paragraph 10.10.)

10.4 AREA ZONE MAP

Due to restricted areal configuration of the City--water on three sides and City-County limits on the other--existing land use has evolved more or less by a process of encroachment and overlapping as opposed to a somewhat

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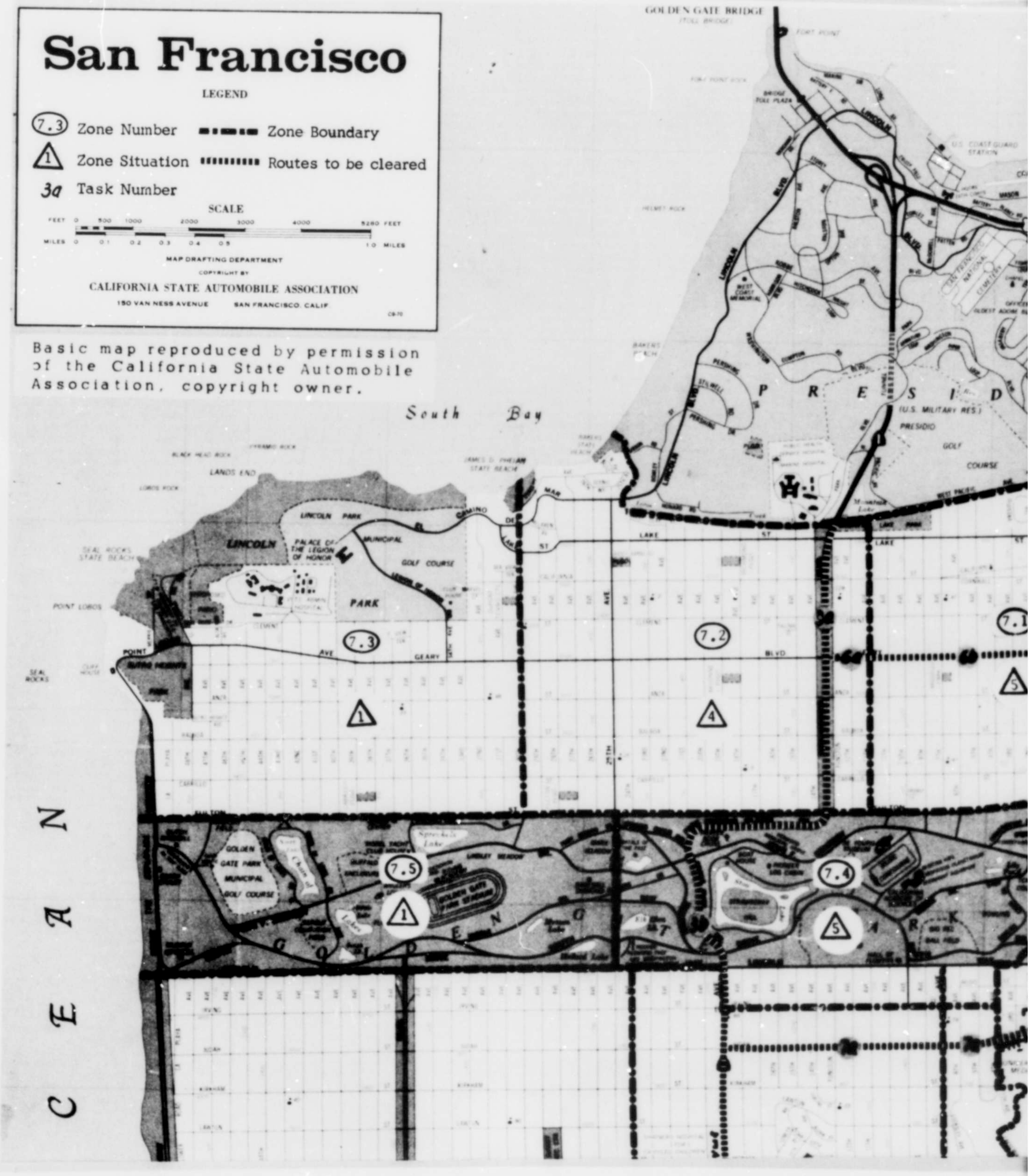
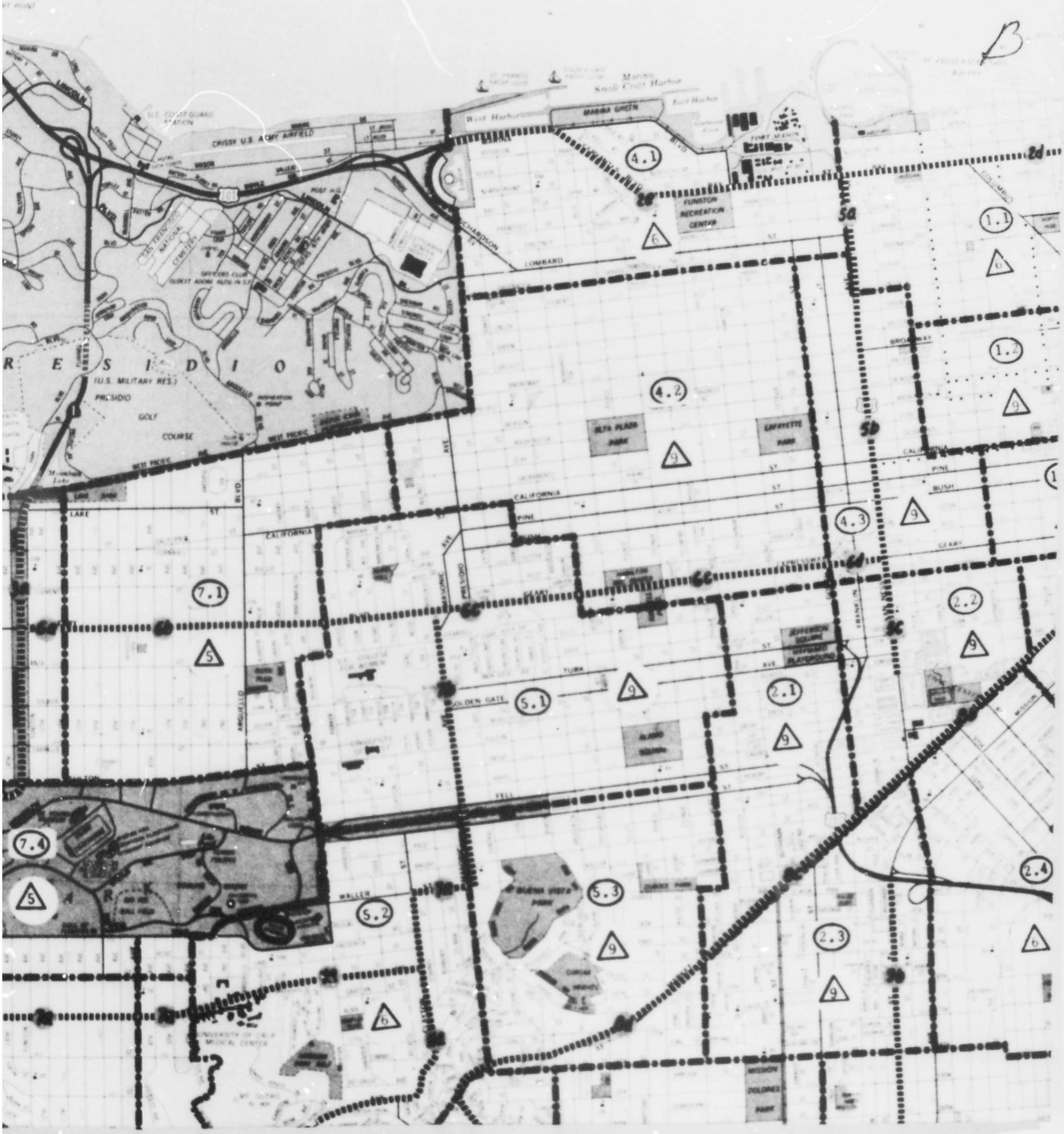
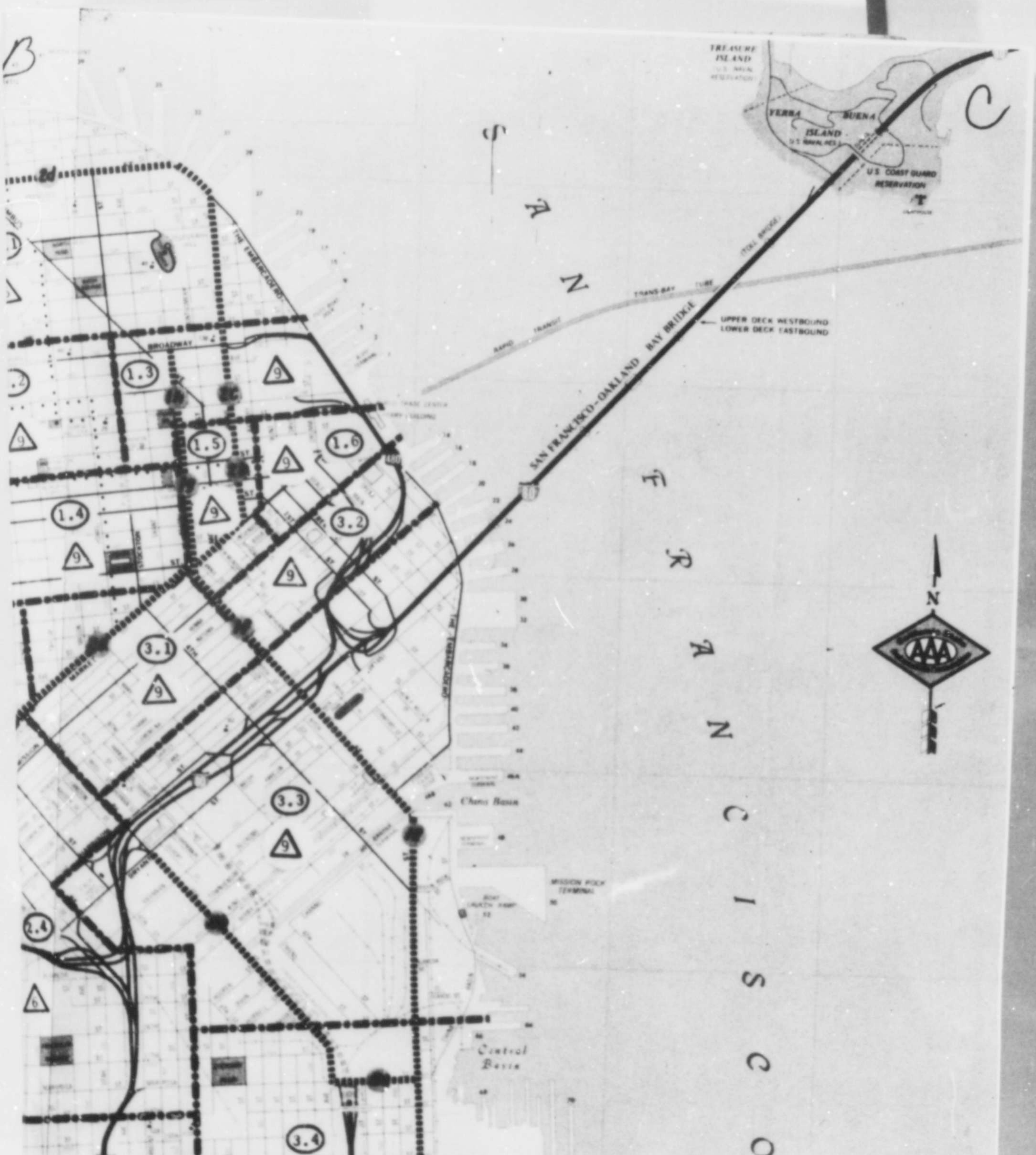


Basic map reproduced by permission of the California State Automobile Association, copyright owner.


B
Marina Small Craft Harbor
West Harbor
East Harbor
MARINA GREEN
U.S. COAST GUARD STATION
CRISSY U.S. ARMY AIRFIELD
SAN FRANCISCO NATIONAL CEMETERY
OFFICERS CLUB OLDEST ADOBE BLDG IN S.F.
P R E S I D I O
(U.S. MILITARY RES.)
PRESIDIO GOLF COURSE
FUNSTON RECREATION CENTER
RICHARDSON
LOMBARD
COLUMBUS
BROADWAY
ALTA PLAZA PARK
LAFAYETTE PARK
CALIFORNIA
PINE
BUSH
GEARY
LAKE
ARGUELLO
PRESIDIO
TURK
GOLDEN GATE
JEFFERSON SQUARE
FELL
WALLER
BUENA VISTA PARK
UNIVERSITY OF CALIF MEDICAL CENTER
MISSION DOLORES PARK
4.1
4.2
4.3
1.1
1.2
2.1
2.2
2.3
2.4
5.1
5.2
5.3
7.1
7.4
5a
5b
5c
6a
6c
2d


B
C
TREASURE ISLAND
YERBA BUENA ISLAND
U.S. COAST GUARD RESERVATION
(TOLL BRIDGE)
TRANS-BAY TUBE
RAPID TRANSIT
SAN FRANCISCO-OAKLAND BAY BRIDGE
UPPER DECK WESTBOUND
LOWER DECK EASTBOUND
S A N F R A N C I S C O
N
THE EMBARCADERO
BROADWAY
1.3
1.5
1.6
1.4
3.1
3.2
3.3
3.4
2.4
9
China Basin
MISSION ROCK TERMINAL
Central Basin

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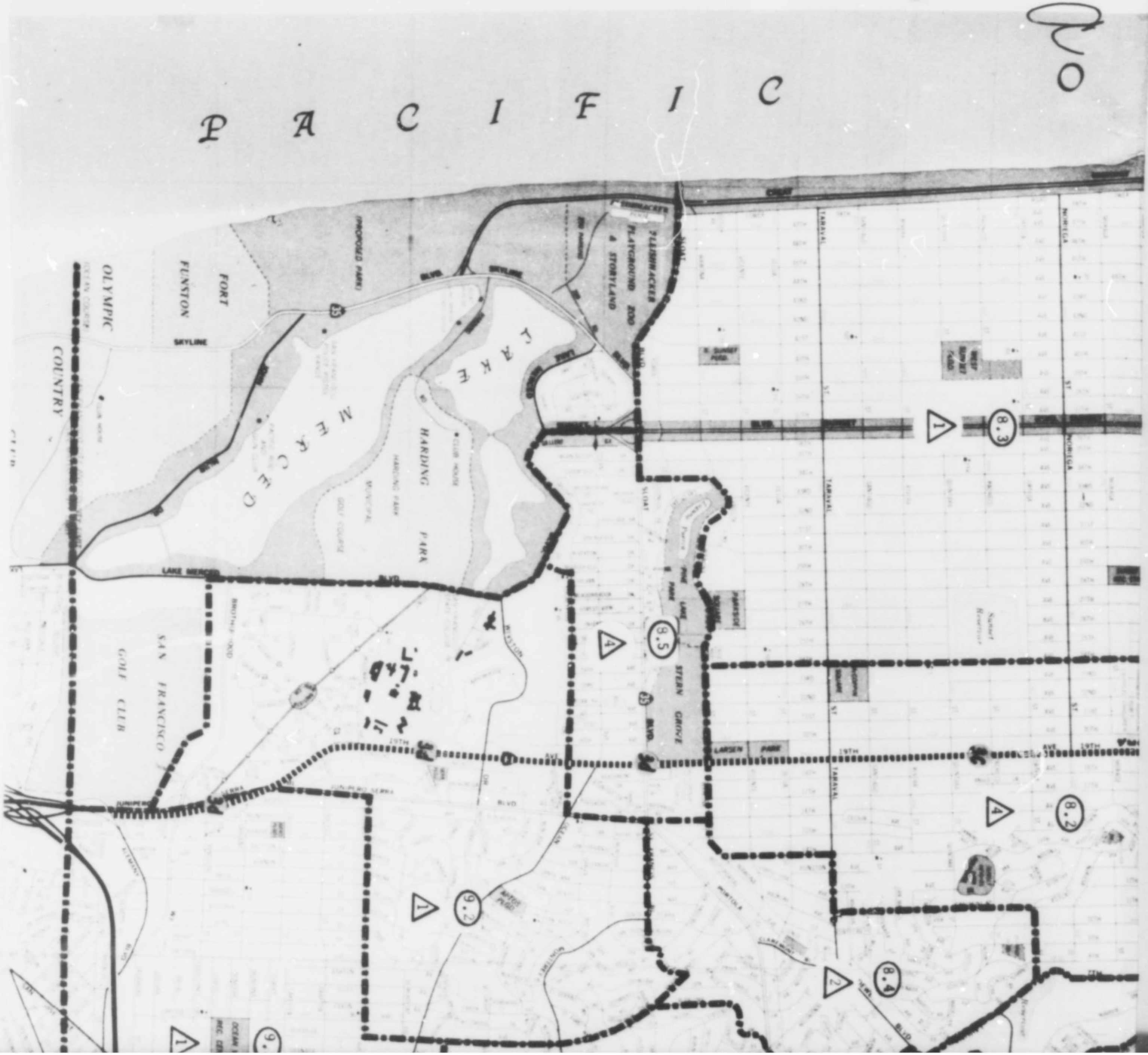
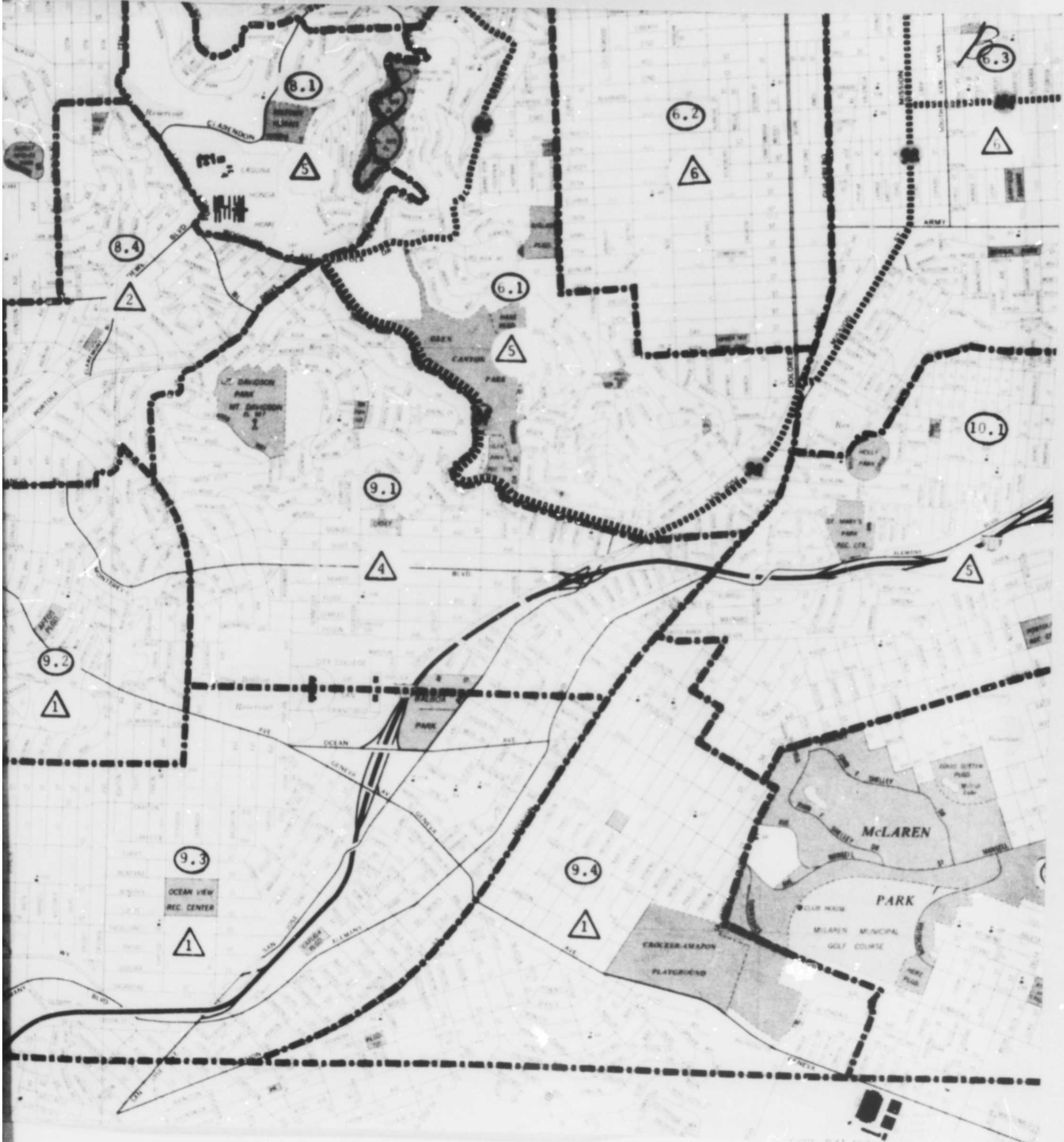
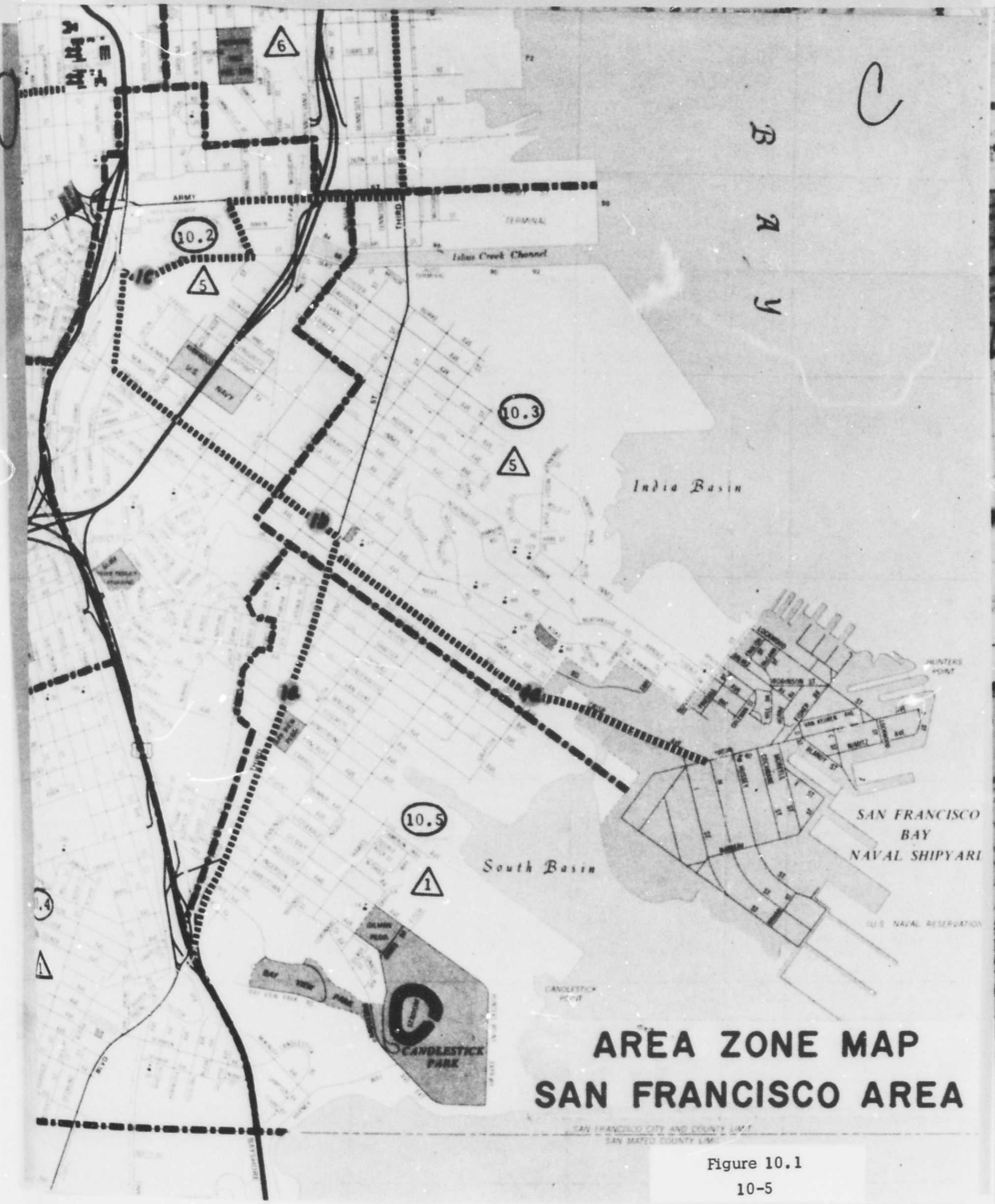

PACIFIC
FLEISHHACKER PLAYGROUND ZOO & STORYLAND
LAKE MERCED
HARDING PARK
HARDING PARK MUNICIPAL GOLF COURSE
FORT FUNSTON
OLYMPIC
COUNTRY
SAN FRANCISCO GOLF CLUB
STERN GROVE
PINE LAKE PARK
PARKSIDE SQUARE
McCOPPIN SQUARE
WEST SUNSET PLGD.
Sunset Reservoir
(PROPOSED PARK)
SKYLINE
NORIEGA
TARAVAL
SLOAT
BLVD.
LAKE MERCED BLVD.
JUNIPERO SERRA
19TH AVE
BROTHERHOOD
8.2
8.3
8.4
8.5
9.2
1
2
4



8.1
6.2
6.3
8.4
6.1
GLEN CANYON PARK
MT. DAVIDSON PARK
9.1
10.1
OCEAN
BLVD
9.2
BALBOA PARK
9.3
OCEAN VIEW REC. CENTER
9.4
McLAREN
PARK
McLAREN MUNICIPAL GOLF COURSE
CROCKER-AMAZON PLAYGROUND



C
BAY
India Basin
South Basin
SAN FRANCISCO
BAY
NAVAL SHIPYARD
HUNTERS POINT
U.S. NAVAL RESERVATION
Islais Creek Channel
ARMY
TERMINAL
THIRD
10.2
10.3
10.5
5
6
1
CANDLESTICK PARK
CANDLESTICK POINT
SAN FRANCISCO CITY AND COUNTY LIMIT
SAN MATEO COUNTY LIMIT
AREA ZONE MAP
SAN FRANCISCO AREA

Figure 10.1

more systematic development that may have been accomplished if area expansion had been possible. Consequently, San Francisco does not lend itself to readily definable zones based solely on land use. The City has, however, been divided into 10 fire districts, which in effect zone the City by building type and configuration with respect to fire-fighting requirements. The fire districts are used also as basic operating areas for the City's Emergency Operations Plan. Zones for planning debris clearing operations were established which coincided as nearly as possible to the existing fire districts.

The zones are numbered as 1.2, 2.4, etc. The whole umber indicating the fire district; the decimal, the zone within the district. The outside perimeter of all zones with the same whole number prefix approximates the corresponding fire district boundary. The number of zones within each district is dependent on variations of building types, height, etc. Fire District 1, which is essentially the "downtown" portion of the City, has 6 zones while some of the other districts have only 3. For purposes of this study, the City has been divided into 42 debris zones, as shown on Figure 10.1.

The area zone map, or modification thereof as may be later determined, is basic to all debris clearing operations. It is used in determining debris environments regardless of attack conditions. Other data and information pertinent to clearing operations can be superimposed on the area zone map by use of transparent overlays or by actual notation.

10.5 DEBRIS PREDICTION SURVEY

The next step in the study was to make some prediction as to possible debris environments resulting from various simulated attacks on the City. This was accomplished by using the D.P.S. method as discussed in Section 4. Several variations in overall procedures were used, primarily to see if comparable results would be obtained. They were as follows:

1. Actual field survey along the designated clearing route, using a two-man team in accordance with procedure set forth in Section 4. This procedure was identified as a "route survey" as opposed to zone survey later discussed. Individual kits were prepared for several routes. They included portion of City map showing the route; instructions as to how inputs A through H of the D.P.S. sheets were to be determined, and the D.P.S. sheets themselves. The team, who had not previously been involved in debris studies, was given a short briefing of the purpose of the survey and sent into the field.

2. The second procedure was the same as Number 1, above, except that Inputs A through F were obtained by using Sanborn maps in the office. After this data was recorded on the appropriate D.P.S. sheets, the team drove along the designated routes and completed data for Inputs G and H.

3. The third procedure was to make a field or office "zone survey". The purpose of this was to see if average or typical debris predictions as determined for an individual zone would be similar to separate debris predictions made for a specific route through the zone.

All predictions of debris environments used for the San Francisco study are based on the individual zone surveys (3 above) except for comparisons of results as previously mentioned.

Alternating between field survey and use of Sanborn maps enabled the team to spot check themselves as to the various inputs such as average height of buildings, etc. The biggest problem was found to be in identifying or correlating building types, Input E, between the field survey and Sanborn map identifications. Although all building types were classified in accordance with table of Figure 4-3, it may be desirable to establish new designations which would more nearly reflect types shown on the Sanborn maps or actual types within a specific study area.

Inputs I through N were completed by use of appropriate factors as given in Section 4. In cases where the D.P.S. sheet listed two predominant building types or uses within the zone, average values of the several applicable factors were used for the various inputs. The same averaging process was used where block sizes or street widths did not fall within the ranges specified. Due to these conditions, it may be worthwhile to expand the range of factors previously given.

The information provided on the top portion of the D.P.S. sheet is indicative of the fixed physical features of the zone. This data would be used in making predictions of debris environment for all assumed or actual attack conditions.

10.6 PREDICTED ENVIRONMENTS

Using input data A through N, predictions were made of debris environments that may be anticipated in any zone of the City as a result of different simulated attacks. Calculations and determinations for inputs (1) through (11) were made in accordance with discussion and procedures of Section 4. Input (11), predicted debris designation or type, was determined as follows: The first digit number was taken as the most difficult (highest numerical value)

as shown on Figure 1.1 with respect to given maximum depth and size shown by inputs 7 and 8. The second digit reflects inputs 9 and 10. Figure 10.2 shows a completed D.P.S. sheet for Zone 1.4. Environment predictions have been made for a range of anticipated overpressures for both blast only and blast and fire conditions. A sheet for each zone would be completed accordingly and used as follows. A simulated attack is assumed which caused an incident overpressure of 16 psi in Zone 1.4 and an uncontrollable fire situation (Blast and Fire Condition). Predicted debris environment for Zone 1.4 under these conditions would be type 4-5 with an average depth of 6.2 feet. The same sheet would be used in post-attack efforts reflecting either field reports or other information transmitted to the control center. Assume that initial field reconnaissance from Zone 1.4 indicated that blast damage was moderate with little or no fire damage; the predicted environment would be debris type 4-4 with an average depth of 7.9 feet. (Most difficult type in the moderate range; Column 2, under blast only conditions.)

Since this study is concerned with one simulated attack, the calculations for environment predictions were made only for one value of incident overpressure in each zone. Figure 10.3 shows a summary of debris environments (type and average depth) as predicted for each of the 42 zones. The indicated overpressures were obtained by using the isobar overlay for a 1-Mt air blast centered over City Hall. (See Figure 10.5) If the same weapon had been detonated over Kezar Stadium, the overlay would have been centered over the stadium and corresponding zone overpressures indicated accordingly. This and potential fire spread which defines either blast only or blast and fire conditions are discussed later.

10.7 TRAFFIC CONTENT

The predicted environments as given on the D.P.S. sheets allow for

D.P.S. Sheet - ZONE NO. 1.4

(A) Block Size 250 x 400 (B) Street Width 70 (C) Building Coverage 90 (D) Ave. Bldg. Height 80

(E) Building Type 14 & 15 (F) Building Use C (G) Trees - Poles

(H) Comments

(I) E.B.S. 103 (J) Contained Vol. 8240 (K) Material Factor: Blast .436 ; Blast and Fire .208

(L) Potential Debris Material: Blast 3590 ; Blast and Fire 1715 (M) Ave. Depth Factor .008 (N) D ÷ B 1.1

PREDICTED ENVIRONMENTS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
							DEBRIS DESCRIPTION				
									CONTENTS		
ATTACK CONDITION	Incident Over-Pressure PSI	Damage Light-L Moderate-M Severe-S	Off Site Factor	Vol. Off Site Debris Cu.Ft./Lin.Ft	Average Depth Feet	Ratio Maximum To Average Depth	Maximum Depth Feet	Maximum Size Inches	Building	Trees Etc.	PREDICTED DEBRIS TYPE
BLAST ONLY	2	L	0	0	-	-					
	4		.014	50	.4	5:1	2.0	27	3	-	2-3
	6	M	.031	111	.9	3:1	2.7	48	4	-	3-4
	8		.274	984	7.9	1:1	7.9	48	4	-	4-4
	10		.400	1436	11.5	1:1	11.5	60	5	-	5-5
	12		.45	1615	12.9	1:1	12.9	60	5	-	5-5
	14	S	.45	1615	12.9	1:1	12.9	60	5	-	5-5
	16		.45	1615	12.9	1:1	12.9	60	5	-	5-5
	50		.45	1615	12.9	1:1	12.9	60	5	-	5-5
BLAST AND FIRE	2	L	0	0	-	-					
	4		.014	24	.2	5:1	1.0	27	3	-	2-3
	6		.031	53	.4	3:1	1.2	48	4	-	3-4
	8	M	.274	470	3.8	1:1	3.8	48	4	-	3-4
	10		.400	686	5.5	1:1	5.5	60	5	-	4-5
	12		.45	770	6.2	1:1	6.2	60	5	-	4-5
	14	S	.45	770	6.2	1:1	6.2	60	5	-	4-5
	16		.45	770	6.2	1:1	6.2	60	5	-	4-5
	50		.45	770	6.2	1:1	6.2	60	5	-	4-5*

*Used for S.F. Study

Figure 10.2

SUMMARY
DEBRIS PREDICTION SURVEY
CITY OF SAN FRANCISCO
SIMULATED ATTACK #1

Zone No.	Incident Overpress.	Blast Only		Blast & Fire	
		Type	Aver. Depth	Type	Aver. Depth
1.1	20	4-3	4.8'	3-3	1.7'
1.2	33	4-3	6.6'	3-3	2.4'
1.3	23	4-4	7.7'	4-4	3.8'
1.4	50	5-5	12.9'	4-5	6.2'
1.5	28	6-5	27.5'	6-5	14.5'
1.6	20	4-5	5.2'	3-5	2.5'
2.1	50	3-3	3.3'	3-3	1.8'
2.2	50	4-5	8.1'	3-5	4.4'
2.3	45	3-2	3.9'	2-3	1.7'
2.4	35	3-5	2.7'	3-5	.8'
3.1	50	5-5	10.6'	4-5	5.8'
3.2	23	4-5	5.2'	4-5	2.8'
3.3	26	3-5	1.2'	3-5	.6'
3.4	12	3-3	.5'	2-3	.1'
4.1	15	3-3	2.0'	2-3	.8'
4.2	30	3-3	2.4'	2-3	1.0'
4.3	40	4-4	5.5'	4-4	2.9'
5.1	26	3-3	3.2'	2-3	1.0'
5.2	15	3-2	2.7'	3-2	1.0'
5.3	30	3-4	2.0'	3-4	.8'
6.1	10	1-2	.8'	1-1	.1'
6.2	15	1-2	1.3'	1-1	.7'
6.3	15	1-2	.8'	2-3	.4'
7.1	10	3-2	1.2'	1-2	.2'
7.2	4	3-2	.5'	1-2	.1'
7.3	3	1-2	.1'	1-2	.1'
7.4	6	3-2	1.0'	1-2	1.0'
7.5	4	3-2	1.0'	1-2	1.0'
8.1	6	3-2	1.1'	1-2	.5'
8.2	4	3-2	.3'	1-2	.1'
8.3	3	1-2	.1'	1-2	.1'
8.4	5	3-2	.7'	1-2	.1'
8.5	3	1-2	.1'	1-2	.1'
9.1	4	3-2	.4'	1-1	.1'
9.2	3	1-2	.1'	1-1	.1'
9.3	3	1-2	.1'	1-1	.1'
9.4	3	1-2	.1'	1-1	.1'
10.1	4	3-2	.4'	1-2	.1'
10.2	8	2-3	.4'	2-3	.1'
10.3	5	1-2	.3'	1-2	.1'
10.4	4	3-2	.4'	1-2	.1'
10.5	4	3-2	.6'	1-2	.2'

Figure 10.3

all factors except possible inclusion of damaged vehicles. This variable factor is dependent on traffic conditions within the zone at time of attack and the actual attack conditions. A tabulation indicating this factor for each study area can be made as shown in Figure 4.12. It is assumed that the attack on San Francisco occurred between the hours of 7 and 9 A.M. on a Tuesday. During these hours, medium to heavy traffic conditions exist throughout the City. Figure 10.4 lists assumed traffic conditions (Parameter B) for the various zones.

10.8 <u>ZONE SITUATIONS</u>

Prediction of debris environments for pre-attack planning purposes can be made from completed D.P.S. sheets using specific overpressures and fire spread data as provided by appropriate attack overlays. In the immediate post-attack period, these predictions could be based on zone situations as discussed in Section 4. See Figure 4.13.

Blast damage as indicated by a zone situation would relate to evaluation shown in column (2) of the D.P.S. sheet. Situations 1, 2 or 3 would apply to blast only condition; situation 7, 8 or 9 to blast and fire conditions. The debris manager would make his own determination with respect to predicting debris environments for a reported situation of 4, 5 or 6.

Initial reporting of zone situations will enable the manager to make at least a first approximation of debris environments to be encountered in completing various tasks. Appropriate resources could be assigned accordingly. As more information becomes available, he may re-assign resources as indicated by revised prediction of the debris environment.

Situations have been assigned each zone in the City on the basis of the assumed attack conditions. They are listed on Figure 10.4.

ZONE SITUATIONS & PARAMETER B
CITY OF SAN FRANCISCO
SIMULATED ATTACK #1

Zone No.	Situation	'B'	Zone No.	Situation	'B'
1.1	6	3	6.2	6	2
1.2	9	3	6.3	6	3
1.3	9	3	7.1	5	2
1.4	9	3	7.2	4	2
1.5	9	3	7.3	1	1
1.6	9	3	7.4	5	2
2.1	9	3	7.5	1	1
2.2	9	3	8.1	5	2
2.3	9	3	8.2	4	2
2.4	9	3	8.3	1	1
3.1	9	3	8.4	2	2
3.2	9	3	8.5	4	2
3.3	9	3	9.1	4	2
3.4	6	2	9.2	1	2
4.1	6	3	9.3	1	2
4.2	9	3	9.4	1	1
4.3	9	3	10.1	5	2
5.1	9	3	10.2	5	2
5.2	6	2	10.3	5	2
5.3	9	2	10.4	1	1
6.1	5	2	10.5	1	1

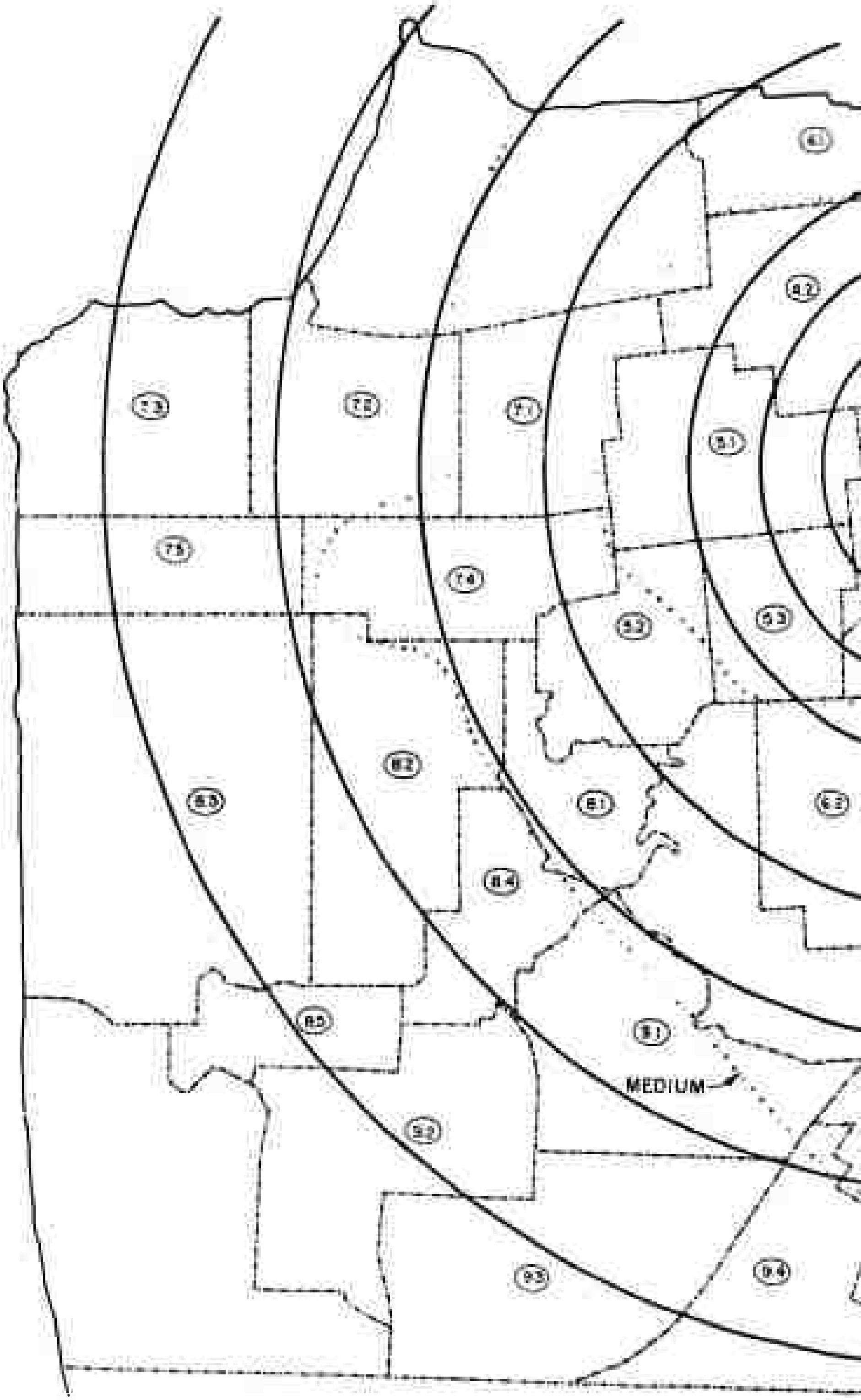
Figure 10.4

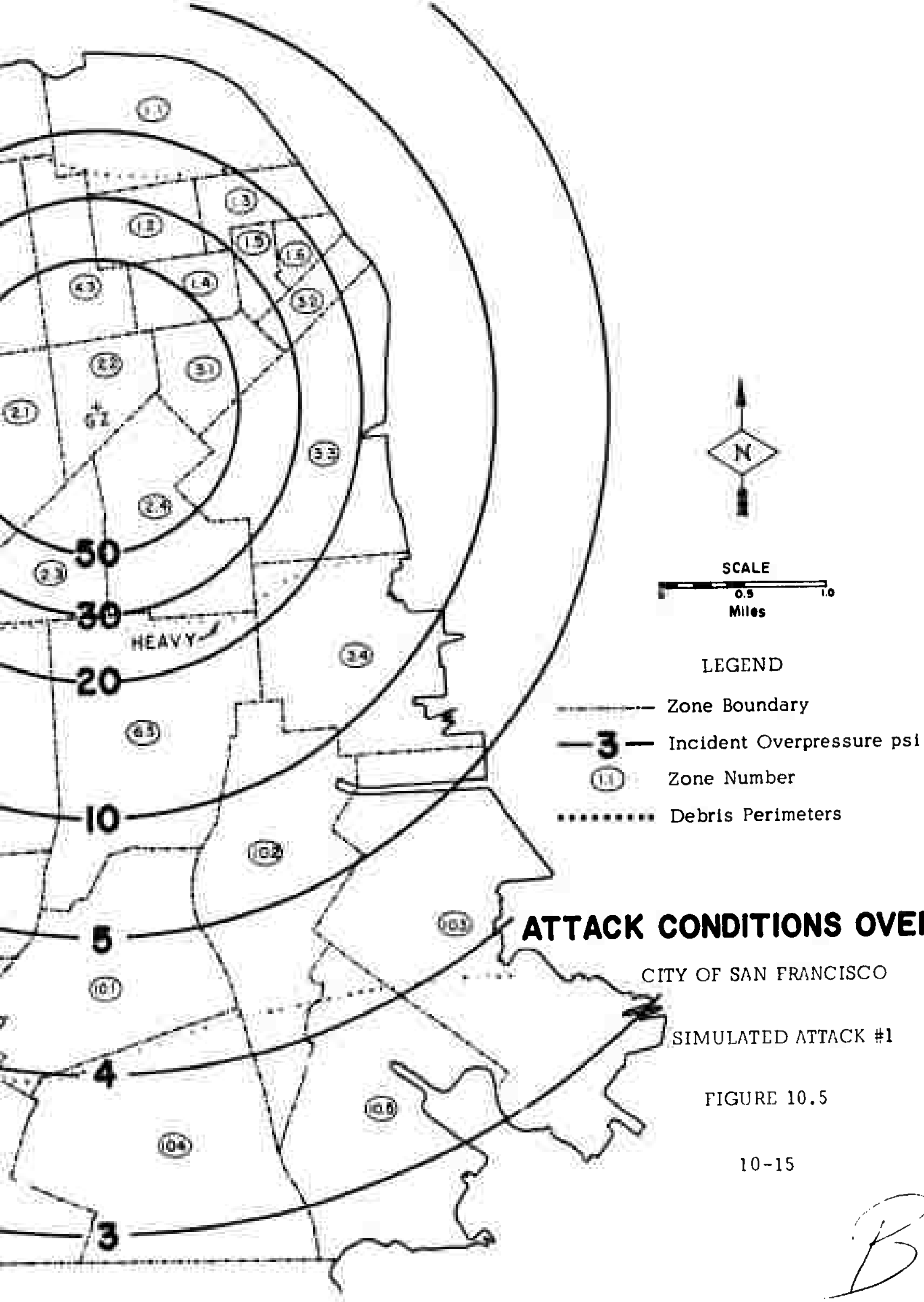
10.9 DEBRIS PERIMETERS

Zone situations as used in this study tend to define predicted type and quantity of debris resulting from various degrees of blast and fire damage as opposed to nine basic operating situations given in Reference 5. In the early post-attack period, however, the two can be related with respect to fire. A basic operating situation of 7, 8 or 9, which indicates an uncontrollable fire condition can be assumed the same as a zone situation of 7, 8 or 9, severe fire damage. Using this relation, it is possible to make an early appraisal of the overall possibility of completing a task. This is accomplished by drawing "debris perimeters" on the area zone map or appropriate overlay. All zones with a situation of 7, 8 or 9 are included within the "heavy perimeter". It would be difficult if not impossible to complete within a reasonable period of time, a task lying within the heavy perimeter area. The medium perimeter is drawn to encompass all zones with a situation of 3, 5 or 6. Tasks lying between the "heavy" and "medium" perimeters could probably be completed as an emergency function. Tasks beyond the "medium" perimeter, zone situations 1, 2 and 4, should present no unusual problems. See Figure 10.5.

This relation of fire conditions between zone and basic operating situations varies with respect to time. Although an operating situation may change from an uncontrollable fire condition (7, 8 or 9) to a negligible fire condition (1, 2 or 3) as fires are extinguished, the zone situation will remain as either 7, 8 or 9; severe fire damage.

The above evaluation of clearing tasks does not allow for the effects of radiation. It is assumed that no task would be started in a zone with a severe fallout situation regardless of its location with respect to the debris perimeters. As mentioned previously, this restraint on clearing operations,


MEDIUM



ATTACK CONDITIONS OVERLAY

CITY OF SAN FRANCISCO

SIMULATED ATTACK #1

FIGURE 10.5

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as well as existing fire conditions, will be indicated by color code on the individual task cards.

10.10 POST ATTACK EVALUATIONS

The previous paragraphs have described the different procedures and data necessary for the evaluation of debris clearing tasks. The area zone map, Figure 10.1, shows the different zones, zone situations and clearing tasks pertaining to the San Francisco study. In an actual situation, other data such as isobars of incident overpressures, anticipated fire spread, debris perimeters, etc. would be shown by a series of transparent overlays placed over the basic area zone map, each overlay depicting certain conditions of the attack and clearing requirements. For purposes of this study, these overlays are combined and shown at reduced scale on Figure 10.5.

Using the area zone map, overlays, completed D.P.S. sheets and Figures 1.2 and 10.4, it is possible to define the debris handling requirements for each of the assumed tasks. For example, consider task 12a. This task is located in Zone 6.3. Length of route as scaled from the map is 3,600 feet. Width of clearing path is 20'. The attack overlay indicates an incident overpressure of 15 psi. A situation of 6 has been assigned to Zone 6.3; severe blast and moderate fire damage. The D.P.S. sheet for Zone 6.3 shows the following environment: blast only condition; debris type 1-2 with an average depth of .8'; for a blast plus fire condition; debris type 2-3 with an average depth of .4'. (See Figure 10.3) For purposes of this example, the blast only condition is used. Quantity of debris is determined to be 2,220 cu.yd. Figure 10.4 shows a value for traffic content (Parameter B) of 3. Adjusted debris type is 2-3. (See Figure 1.2.) Task 12a involves the handling of 2,220 cu.yds. of type 2-3 debris.

Similar evaluations were made for all tasks. As previously mentioned, the twelve designated clearing routes have been considered by individual tasks, each reflecting a different debris environment (or type) as determined for the zone through which the route passes. A tabulation of all tasks can be made by using the form shown on Figure 2.1. Figure 10.6 is a partial listing used for the San Francisco study. A summary of the anticipated quantity of debris to be handled in clearing the designated routes is shown on Figure 10.7. Quantities are listed by debris types. They are based on "blast only" conditions except for tasks in zones having a situation number of 7, 8 or 9, where factors reflecting a "blast and fire" condition were used.

Total quantity of debris to be handled is estimated to be approximately 550,000 cu.yd. If blast only condition had been used for all calculations, the total quantity would be approximately 920,000 cu.yds. These quantities are indicative of the overall magnitude of debris clearing requirements. They represent only a small percentage of the total quantity which ultimately may have to be cleared from the City of San Francisco.

As mentioned in paragraph 10.5, several variations of the D.P.S. method were used to determine average depth of debris which in turn dictates total quantity. Comparative results for "blast only" condition were as follows. Quantity as determined for Route #1 based on profile given in Reference 6 was 148,000 cu.yds.; based on a route survey, the total was 182,000 cu.yds. Using a zone survey, the quantity was 167,000 cu.yds. Results of other comparable route and zone surveys indicated that, in general, a route survey gave greater quantities of debris than determined by a zone survey. This was anticipated as most designated routes were along major thoroughfares where building densities were usually higher than average conditions in the zone. Variations in total quantities were in the range

TASK DEFINITION

TASK NUMBER	PARAMETER A: TYPE OF DEBRIS 1	A: TYPE OF DEBRIS 2	B: TRAFFIC CONTENT	C: TYPE OF OPERATION	D: DEBRIS QUANTITY d (Feet) 1	w (Feet) 2	W (Feet) 3	L (1000 Feet) 4	V (1000 Cu.Yd.) 5	E: HOURS ALLOWED	F: PRIORITY
1a	3	2	1	7	.6	50	70	6.2	7.0	20	Priorities to be assigned by D & C
1b	1	2	2	7	.3	50	80	1.9	1.1	3	
1c	2	3	2	7	.4	50	80	9.4	7.0	20	
1d	3	3	2	7	.5	50	80	7.6	7.1	24	
1e	3	5	3	7	.6	50	80	7.1	8.0	30	
1f	4	5	3	8	5.8	50	80	1.9	22.0	80	
1g	4	5	3	8	6.2	50	80	1.9	24.5	120	
1h	4	4	3	8	3.8	50	80	1.6	12.1	48	
2a	4	5	3	8	5.8	50	80	1.0	12.0	70	
2b	6	5	3	9	14.5	50	80	2.9	10.0	800	
2c	4	4	3	8	3.8	50	80	1.7	12.9	60	
2d	4	3	3	8	4.8	50	80	8.8	35.7	300	
2e	3	3	3	7	2.0	50	80	7.5	29.1	100	
3a	3	2	2	7	0.5	50	80	5.0	4.7	25	
3b	3	2	2	7	1.0	50	80	5.4	10.1	25	
3c	3	2	2	7	0.3	50	80	10.5	5.9	20	
3d	1	2	2	7	0.1	50	80	10.4	1.9	15	
4a	1	2	2	7	0.3	50	80	9.1	5.1	15	

Figure 10.6

SUMMARY - DEBRIS QUANTITIES
CITY OF SAN FRANCISCO
SIMULATED ATTACK #1

Task No.	QUANTITY OF DEBRIS (CU.YDS.) BY TYPE										Total Per Task Cu.Yds.
	2-3	3-3	3-4	3-5	4-3	4-4	5-3	5-4	5-5	6-5	
1	1,090	7,050	6,975		7,105		7,985		59,390		89,595
2						29,060		85,710	24,855	100,430	240,055
3	1,925			20,635							22,560
4	5,125										5,125
5							9,820	12,680	18,355		40,855
6			10,350	6,710					3,350		20,410
7			4,140	27,855							31,995
8	7,370		7,400	4,520		4,095	22,160		19,995		65,540
9	11,375		5,900								17,275
10					1,610		2,655				4,265
11				8,630							8,630
12	2,220										2,220
Totals	29,105	7,050	34,765	68,350	8,715	33,155	42,620	98,390	125,945	100,430	548,525

Note: Quantities and types reflect blast & fire conditions for all zones with situations of 7, 8 or 9.

Figure 10.7

of plus or minus 20 to 40%. Considering the large uncertainties of all factors relating to nuclear attacks, it is felt that either D.P.S. method would provide reasonable basis for determining clearing operation requirements. The choice would lie with those in charge of debris studies for each specific study area. The physical features and configuration of an area would probably indicate which method, either route or zone surveys, would be most appropriate.

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SECTION 11
SAN FRANCISCO STUDY
RESOURCE INVENTORY, ASSIGNMENT & TOTAL REQUIRED RESOURCES

11.1 INTRODUCTION

In this phase of the study, inventories of the resources of the San Francisco area were made. The essential resources that were located and tabulated were: key debris removing equipment, petroleum stocks, repair parts sources and manpower for organization and operation. The key equipment was placed into groups which were considered best to deal with the various tasks likely to be allocated to them.

The most appropriate groups were then matched to the various clearing tasks outlined in Section 10 of this study. It was then possible to compute the total effort in equipment, P.O.L. and manhours required to carry out these tasks.

11.2 EQUIPMENT INVENTORY

An inventory of key equipment was made for the City of San Francisco and for the areas that were considered sufficiently near to the City to be able to provide key equipment in time for it to be used on emergency clearing tasks. In the simulated attack condition, the estimated damage should be light in the outlying districts where the equipment normally is located, so that it is presumed to be made available for use in San Francisco. These additional areas were the Mid-Peninsula (south of the City to Redwood City), the South Peninsula (Redwood City to San Jose), Marin (Marin County), and the East Bay (Richmond to Hayward and east to San Leandro).

The key equipment considered was limited to bulldozers, front-end loaders, shovels and motor graders. It was realized that dump trucks,

supply trucks and low-bed trailers for transport would be needed for successful clearing operations, but it was considered that they would be available in sufficient quantities from the same sources as the key equipment.

Contractors and dealers were contacted and their presently available key equipment was recorded on Equipment Inventory Locator cards. A typical completed card is shown on Figure 11.1. Most of the contractors were drawn from a list of members provided by the Peninsula Chapter of the Engineering and Grading Contractors Association. The local dealers for the major earthmoving equipment manufacturers contacted were listed from the current "Annual Equipment Index" of Western Construction magazine or from the Yellow Pages of the telephone directory. Some forty sources were inventoried and continuing studies would increase this number substantially. More than one hundred bulldozers and 160 front-end loaders were counted. These are the most critical pieces of equipment for the presumed conditions and adequate to perform the tasks listed in this study.

It was found that practically all the key equipment located in the City was in one zone (10.3), an outlying area to the south. San Francisco is probably unique in such concentration of equipment and other cities could be expected to have a more even distribution of key equipment. The greater part of the total quantity of equipment located was outside the city limits. The City public works department and the various utilities had little or no equipment in the key categories. The large contractors working on various major buildings and BARTD structures also seemed to have little appropriate earthmoving equipment.

Large contractors with their home base in this area are poor prospects for locally stocked equipment but could be very valuable as sources of management personnel or advisors. It is noteworthy that there are very

EQUIPMENT INVENTORY - LOCATOR

SOURCE OR FIRM Flora Crane Service, Inc. LOCATION SERIAL NO. 101

STREET (OFFICE) 250 Mendell CITY San Francisco

PHONE 285-2500 RADIO FREQUENCY -

STREET (STORAGE YARD) 250 Mendell CITY. San Francisco

PHONE 285-2500 CONTACT(S) Bob Flora and Office Manager

Equipment	Type	H.P. Or Cap.		Code	Manufacturer	Model	Condition	No
		Value	Unit					
Bulldozer	Crawler	270	H.P.	286	Caterpiller	D8		1
"	"	120	H.P.	280	"	D6		1
Shovels	"	2-1/2	C.Y.	264	Northwest	80D		2
F.E. Loaders	Crawler	177	H.P.	162	Caterpiller	977		2
" "	"	115	H.P.	160	"	955		1
" "	Wheel	150	H.P.	163	"	966		1
" "	"	192	H.P.	163	Wabco	350		2
" "	"	208	H.P.	165	"	400		3
Motor Grader	Wheel	115	H.P.	141	Caterpiller	12		1

Figure 11.1

few power shovels in this area.

Each source of equipment was given an equipment yard serial number, by zone - Figure 11.2. An Equipment Inventory Summary was made out for Zone 10.3 of the City as well as for each of the four nearby areas mentioned previously. A sample Zone Summary card is shown on Figure 11.3 and the Total Equipment Inventory Summary was then completed for the whole area and is shown on Figure 11.4. A map showing the position of individual sources of key equipment was drawn up (Figure 5.3). Most of the equipment was either close together in one zone of the City, or could be brought from outside the City to designated MSA's, during increased readiness alert.

Equipment Parts Locator cards were completed for the various units of key equipment used in this study. The information was obtained from the current "Annual Equipment Index" of Western Construction magazine. An example of a completed card is shown on Figure 11.5.

11.3 MANPOWER RESOURCES

The debris clearing manager will require the assistance of management personnel from industry who for the most part are successful contractors or their key personnel. Executive officers of the E.G.C.A. were listed as key management personnel on Figure 11.6. Others listed were consultants in the field, and an officer of the ASCE. General contractors with headquarters in the area, who have experience in large construction endeavors on a world-wide basis but who may not otherwise be active locally in construction would be additional sources of management personnel.

Discussion with the Operating Engineers of the AFL-CIO with respect to establishment of a cadre of key operators resulted in the listing in Figure 11.7 not of individual operators, but union representatives from the various districts in the area. It was considered that these people would mobilize

SERIAL NUMBER ASSIGNMENTS

CITY: San Francisco ZONE: 10-3

OWNER	YARD LOCATION	SER. NO.
Flora Crane	250 Mendell	101
Chet C. Smith	2170 Oakdale Avenue	102
Morgan Equipment	1755 Evans	103
Fred Early	369 Pine (Office)	104

Figure 11.2

KEY EQUIPMENT INVENTORY
ZONE SUMMARY

ZONE NO. 10.3 SITUATION: ______ DATE 2/1/71

QUANTITY

Owner Serial No.	EQUIPMENT CODE											
	288	286	284	280	264	162	160	159	165	163	161	141
101		1		2	2	2	1		3	3		1
102	1	3	3			5	2	1				
103		3								2	4	
104				4					1			

Figure 11.3.

KEY EQUIPMENT INVENTORY SUMMARY

CITY OR AREA: San Francisco

DATE 2/1/71

QUANTITY

	EQUIPMENT CODE											
Zone No.	288	286	284	280	289	283	166	162	160	169	167	165
10.3	1	7	3	6	-	-	-	7	3	1	-	4
Mid.Pen.	3	10	-	6	-	-	1	-	-	-	2	-
Sou.Pen.	7	11	-	7	4	1	-	7	3	4	5	5
East Bay	2	4	9	8	-	-	-	8	8	-	2	11
Marin	-	5	-	4	-	-	-	4	5	-	-	-
Total	13	37	12	31	4	1	1	26	19	5	9	20

	EQUIPMENT CODE											
Zone No.	163	161	176	264	145	141						
10.3	5	4	-	2	-	1						
Mid Pen.	3	3	1	4	-	2						
Sou.Pen.	3	5	-	2	-	25						
East Bay	11	5	-	-	2	6						
Marin	1	-	-	-	-	5						
Total	23	17	1	8	2	39						

Figure 11.4

EQUIPMENT PARTS LOCATOR

MANUFACTURER: Caterpillar   DATE: 3-4-71

EQUIPMENT: Dozers, Front End Loaders, & Graders

FACTORY ADDRESS (MAIN OFFICE)	(BRANCH)
STREET –	
CITY Peoria, Illinois	
PHONE 309-676-3311 RADIO	
CONTACTS Ralph E. Ehni	

LOCAL DISTRIBUTOR NAME: Peterson Tractor Co.

STREET 955 Marina Boulevard

CITY San Leandro

PHONE 357-6200 RADIO

CONTACTS Mike Patrick

NEAREST DISTRIBUTOR ELSEWHERE: NAME: Holt Bros.

STREET E. Highway 4

CITY Stockton

PHONE 209-466-6000 RADIO

CONTACTS

OTHER IMPORTANT PARTS SOURCES:

Peterson Tractor Co. @ Chico

Figure 11.5

KEY PERSONNEL (Management)

No.	Name and Affiliation	Business Address	Phone	Home Address	Phone
1	George E. Wickham, Partner Jacobs Associates	50C Sansome Street San Francisco	434- 1822	190 Manor Drive Mill Valley, California	388- 5764
2	Larry Farrens, President Pen.Chapt. E.G.C.A.	500 Phelan Avenue San Jose, CA 95112	(408) 287- 5765	203 Warwick Drive, Campbell, California	(408) 378- 0756
3	Ted Holmes, Vice President Pen.Chapt. E.G.C.A.	2500 Sondgroth Way Mountain View, CA 94040	967- 2125	575 South Rengstorff Ave. Mountain View, CA	969- 3287
4	Carl Aparicio, Secretary Pen.Chapt. E.G.C.A.	506 Phelan Avenue San Jose, CA 95112	(408) 286- 4580	1216 Greenbriar Avenue San Jose, CA	(408) 243- 7239
5	Arthur Perham, Past Pres. Pen. Chapt. E.G.C.A.	7400 St. Joseph Avenue Los Altos, CA 94022	967- 8252	10700 St. Joseph Ave. Los Altos, CA	948- 1952
6	Albert LaVigne, President A.S.C.E. San Francisco Section	149 N. Montgomery San Francisco	982- 8338	42 El Camino Moraga Orinda, CA	376- 5801

Figure 11.6

KEY PERSONNEL (Operators)

No.	Name and Affiliation	Business Address	Phone	Home Address	Phone
1	Buck Hope , District Rep. Operating Eng. Local #3	474 Valencia San Francisco	431- 5744	This information to be obtained later.	
2	Don Kinchlow, District Rep. Operating Eng. Local #3	1444 Webster Oakland, CA	893- 2120		
3	Bill Raney, District Rep. Operating Eng. Local #3	1527 South Boulevard San Mateo, CA	345- 8237		
4	Bob Mayfield, District Rep. Operating Eng. Local #3	760 Emory San Jose, CA	(408) 295- 8788		
5	Al Hansen, District Rep. Operating Eng. Local #3	76 Belvedere San Rafael, CA	454- 3565		

Figure 11.7

the required operators during the increased readiness period. Future studies could supplement the union officials by a list of names of more or less permanently located skilled personnel in the event the union offices would not survive the attack. The study determined that there were presently about 200 heavy construction equipment operators in the area.

11.4 P.O.L. INVENTORY

Figure 11.8 shows details of some of the major commercially available P.O.L. sources in the area with their approximate normal stocks. These fuel and lubricant suppliers provided their normal stocks and storage locations only upon verifying the authenticity of this study. It should be noted that a large stock of P.O.L. is located and concentrated at the Brisbane Southern Pacific Pipeline Terminal.

11.5 RESOURCE ASSIGNMENT

Group Cards were made up from the various zone inventory summaries. Sample cards are shown on Figures 11.9 and 11.10. The groups contained no more than three items of major equipment and were arranged to be able to deal with one of the three types of clearing operations described in paragraph 2.3. As far as possible, the groups also were arranged to be most effective in one of the three access route widths likely to be encountered on carrying out the clearing tasks. For example, groups with three 270 HP to 350 HP bulldozers were made up for clearing 50' routes with nominal debris depths. Other groups with two 270 HP bulldozers as major equipment were formed for 30 ft. routes. After groups were formed the Zone Resource Group Inventory Cards were made for each zone. They list groups by group number and show production capacity, types of operation and location. Figure 11.11 shows this card for Zone 10.3.

P.O.L. SOURCES

DATE March 8, 1971

CITY San Francisco

SUPPLIER NAME AND PHONE NUMBER	STOCK LOCATION STREET AND CITY	ZONE	NORMAL STOCK			
			Diesel	Gaso-line	Lubr. Oils	Grease Lb.
1 – Olympian Oil Co. Gulf Oil Jobbers 415 – 761-2244	39 S. Linden South San Francisco	Mid-Penin-sula	45,000	110,000	10,000	5,000
2 – Pacific Petroleum Co. 415 – 632-9131	7929 San Leandro Oakland, CA	East Bay	0	0	500,000	20,000
3 – Phillips Pet. Co. of San Mateo 349-3166	66 Bovet Road, San Mateo at Brisbane S.P. Pipeline Contract Storage	Mid-Penin-sula	2 million	2 million	17,000	5,000
4 – Union Oil Co. 415 – 362-7600 (Mr. Plunkett)	Brisbane S.P. Pipeline Contract Storage	Mid-Penin-sula	420,000	1.7 million	15,000	7,000
	San Jose S.P. Pipeline Contract Storage	South Penin-sula	420,000	1.7 million	15,000	7,000

Figure 11.6

GROUP CARD

GROUP: 8 ZONE: 10.3 DATE FORMED: 3/22/71 DATE DISSOLVED: ______

RESOURCE-CODE/LOCATION	No. Req.	Labor: Manhour - Skill: Operating M.H.	Labor: Operating Skill	Labor: Maintenance M.H.	Labor: Maintenance Skill	Labor: Other M.H.	Labor: Other Skill	Fuel: Diesel Gal.	Fuel: Gasoline Gal.	Lube Lb.	Oil Gal.
Major Equipment											
284/103	1	1	1	.30	2			11.3		.50	.25
165/101	.2	1	1	.37	2			10.5		.70	.22
Minor Equipment											
751	.2	.2	3	.02	2				.4	.01	.01
755	.2	.2	3	.02	2				.4	.01	.01
753	.1	.1	3	.01	2				.2	.01	.01
315	2	2	3	.40	2			14.0		.28	.10
Other Labor											
4	2					2	4				
Hourly Requirements		2.0 2.5	1 3	1.12	2	2	4	35.8	1.0	1.51	.60

STANDARD PRODUCTION - CU.YD./HR.: 580 TYPE OF OPERATION: 2 & 5

Figure 11.9

GROUP CARD

GROUP: 9 ZONE: 10.3 DATE FORMED: 3/23/71 DATE DISSOLVED: ______

RESOURCE-CODE/LOCATION	No. Req.	REQUIREMENTS FOR ONE HOUR GROUP OPERATION									
		LABOR: MANHOUR - SKILL						FUEL			
		Operating		Maintenance		Other		Diesel Gal.	Gasoline Gal.	Lube Lb.	Oil Gal.
		M.H.	Skill	M.H.	Skill	M.H.	Skill				
Major Equipment											
264/101	1	1	1	.33	2			5.0		.40	.14
280/101	1	1	1	.20	2			9.5		1.20	.20
Minor Equipment											
313	2	2	3	.30	2			12.0		.24	.08
751	.15	.15	3	.02	2				.3	.01	.01
755	.15	.15	3	.02	2				.3	.01	.01
602	1								.8	.01	.01
Other Labor											
4	3					3	4				
Hourly Requirements		2 2.3	1 3	.87	2	3	4	26.5	1.4	1.87	.45

STANDARD PRODUCTION - CU.YD./HR.: 360 TYPE OF OPERATION: 5 & 8

Figure 11.10

ZONE RESOURCE GROUP INVENTORY

Zone	Group No.	Date		Operation Type	Standard Product. Cy/Hr.	Owner or Yard Serial #
		Start	Stop			
10.3	1	3/23		4&7	540	101
10.3	2	3/23		4&7	540	102
"	3	3/23		4&7	800	102
"	4	3/23		7	1200	103
"	5	3/23		1&4	470	103 & 104
"	6	3/23		2&5	470	102 & 103
"	7	2/23		5&8	710	101 & 102
"	8	2/23		2&5	580	101 & 103
"	9			2,5&8	360	101 & 104
"	10			3,6&9	405	101
"	11	2/23		6&9	500	101
"	12	2/23		2,5&8	660	102
"	13			3&6	285	101
"	14			6&9	620	103 & 104
"	15			6&9	380	102
"	16			2&5	325	101 & 104

Figure 11.11

Task Requirement Cards for three tasks in route #5 are shown on Figures 11.12 to 11.14. These are representative of the individual task requirement cards made up to clear the 12 routes. Note that "Fallout" and "Fire" conditions on the cards are color coded Yellow. This means that within the zone location of the individual tasks, there is negligible fallout and negligible fire conditions. This may not be the case but is considered to be so for the purpose of this study. The color coding used is in accord with the Alpha Neop Plan proposed by Stanford Research Institute.

For the purpose of this study, work on the first tasks was assumed to start at 1800 hrs. on Tuesday, March 23. This was 10 hours after the 1-Mt air burst mentioned in Section 10.

Using the Zone Resource Inventory, the most suitable groups were assigned to the various individual tasks. In this assignment of groups to tasks, the inventories were searched for groups with high standard production having an operation type corresponding to that on the Task Requirement Card. Consideration also was given to the task location relative to a potential MSA location where the equipment would have been mobilized during increased readiness. For example, groups from the Southern Peninsula area were assembled at a presumed MSA at the San Francisco Golf Club and used mainly on tasks in the western zones of the City.

Each of the groups selected as possibilities for a given task were evaluated on the Resource Evaluation section of the task card as to time required to complete the task. In this evaluation, the adjusted hourly production was determined by multiplying the standard production given on the group card by two factors. The first was a factor which reflected varying difficulties in the clearing operation caused by the various contents of the debris. This factor was obtained from Figure 3.3. The second factor reflected the

TASK REQUIREMENT CARD

Task Requirement Summary

Zone Situation: 6 Fall Out: "Yellow" Fire Condition: "Yellow"

Task No: 5a Zone: 1.1 Date: 3/23 Priority: ______

Route Width: 30' Street Width: 80' Average Depth: 4.8' Length: 2.05

Operation Type: 5 Time Allowed-Hrs: 160 Finish Day: 3/30 Hr: 10.00

Debris Type: 4-3 Variable Cont: 3 Adjusted Debris Type: 5-4

Volume: 12680 Req.Prod: 79

Resource Evaluation

Group		Production Cu.Yd./Hr.				Time - Hours		
No.	Zone	Standard Prod.	Factors Comp.	Factors Units	Adjusted	Mobil.	Oper.	Total
9	10.3	360	.23	.70	58	10	219	229
8	10.3	580	.23	.70	93	10*	136	146

*Mobilized by Water

Supporting Resources

Code	Quantity
620	3
621	3
622	-
072	.5

Resource Assignment:

Group No. 8

Start Day 3/23 Hour 18.00

Finish Day 3/29 Hour 20.00 Gross Oper.Time 142

Labor Hrs.by skill: 1 355 2 186 3 1207 4 234

Labor Total Hrs: 2032

Dies.(gal): 5507 Gas(gal) 142 Lube(lb.) 235 Oil (gal.) 91

Figure 11.12

TASK REQUIREMENT CARD

Task Requirement Summary

Zone Situation: 9 Fall Out: "Yellow" Fire Condition: "Yellow"

Task No: 5b Zone: 4.3 Date: 3/23 Priority:

Route Width: 30' Street Width: 80' Average Depth: 2.9' Length: 5.20

Operation Type: 5 Time Allowed-Hrs: 200 Finish Day: 4/7 Hr: 18.00

Debris Type: 4-4 Variable Cont: 3 Adjusted Debris Type: 5-5

Volume: 18,355 Req.Prod: 92

Resource Evaluation

Group		Production Cu.Yd./Hr.				Time - Hours		
No.	Zone	Standard Prod.	Factors		Adjusted	Mobil.	Oper.	Total
			Comp.	Units				
33	East Bay	770	.17	.7	92	24*	200	224
8	10.3	580	.17	.7	69	0	266	266

*This group from East Bay will mobilize in 24 hours from 3/28 @ 20.00 hrs., but will be ready to start sub-task 5b on completion of sub-task 5a on 3/29 a 20.00 hrs.

Supporting Resources

Code	Quantity
620	2
621	2
622	-
072	0.3

Resource Assignment:

Group No. 33

Start Day 3/28 Hour 20.00

Finish Day 4/7 Hour 04.00 Gross Oper.Time 214

Labor Hrs.by skill: 1 492 2 294 3 1391 4 640

Labor Total Hrs: 2817

Dies.(gal): 9164 Gas(gal) 214 Lube(lb.) 439 Oil (gal.) 167

Figure 11.13

TASK REQUIREMENT CARD

Task Requirement Summary

Zone Situation: 9 Fall Out: "Yellow" Fire Condition: "Yellow"

Task No: 5c Zone: 2.2 Date: 3/23 Priority: ____

Route Width: 30' Street Width: 80' Average Depth: 4.4' Length: 1.75'

Operation Type: 5 Time Allowed-Hrs: 54 Finish Day: 4/9 Hr: 24.00

Debris Type: 3-5 Variable Cont: 3 Adjusted Debris Type: 5-3

Volume: 9820 Req.Prod: 180

Resource Evaluation

Group		Production Cu.Yd./Hr.				Time - Hours		
No.	Zone	Standard Prod.	Factors Comp.	Factors Units	Adjusted	Mobil.	Oper.	Total
8	10.3	580	.35	.70	142	0	69	69
33	East Bay	770	.35	.70	190	0	52	52

Supporting Resources

Code	Quantity
620	3
621	3
622	1
072	0.5

Resource Assignment:

Group No. 33

Start Day 4/7 Hour 04.00

Finish Day 4/9 Hour 08.00 Gross Oper.Time 52

Labor Hrs.by skill: 1 130 2 76 3 454 4 260

Labor Total Hrs: 920

Dies.(gal): 2293 Gas(gal) 52 Lube(lb.) 115 Oil (gal.) 42

Figure 11.14

reduction in production to be expected when multiple units of major equipment were working in the limited working space of the route width. This was obtained by dividing the appropriate factor from Figure 3.4 by the number of major units in the group. With "combination" groups, as determined from Figure 2.2, (such as were employed for task 5a), the unit factor was first averaged between the two different types of equipment and then divided by the number of major units. For example, group 8 on task 5a (Figure 11.12) contained a bulldozer (Code 284) and an end dump front-end loader (Code 165).

$$\text{Multiple Unit Factor} = \frac{1.6 + 1.2}{2} \div 2 = 0.7$$

The group which had the capability to complete the task most quickly, and within the time allowed, was selected.

Attached to the selected group were additional sets of tools and supplies for cutting steel and wood debris as required, and the personnel to perform such tasks. The required quantities of these support resources varied with the debris characteristics as indicated on Figure 8.5 . Where the debris depth and type required it, a crane was attached to the selected group to handle heavy pieces of structural steel and other large pieces of debris.

Computer application to the problem of group and task matching and group availability is not within the scope of this study, but in a situation where there were a large number of groups and a multitude of tasks, the groups could be given code numbers which indicate the major equipment they contain. These code numbers could be compared by the computer with the various individual tasks and the most suitable available group selected, task duration times forecast, and P.O.L. and manpower requirements could be predicted. Computer analysis may provide a planning tool and might be

useful in the post-attack period. In any event, it is essential to code the equipment by type and capacity to avoid confusion in considering the many sizes and types which may be available and interchangeable.

It was found useful to employ a bar chart (see Figure 11.15) in order to determine the availability and location of the various groups at any given time. From the bar chart it can be seen that, in some cases, as many as three groups are employed in clearing a given individual task at the same time.

There were two task situations in which "multi-group" debris clearing was employed. The first was when a route could be tackled from both ends. Route #3 (see zone map Figure 10.1) illustrates this. Groups 20 and 21 were assembled at the San Francisco Golf Club MSA, having been mobilized from the Mid-Peninsula area. Group 21 was considered to start immediately on the southern end of task 3d and then on to task 3c. Group 20 was mobilized to the north end of task 3a. This mobilization was estimated to take six hours and to be carried out under the equipment's own power via the Great Highway. Group 20 could complete task 3a and then both groups could tackle task 3b, one from each end. A second type of multi-group operation is illustrated by Route #1. In this case, task 1f was started in three places by three groups equipped to deal with combination type operations (see Section 2 of this study). Each of these groups had "all crawler" major equipment. The assumption was that the "all crawler" groups could travel over debris of average depth without having first to clear an access route. These groups (12, 17 and 18) could by-pass tasks 1a through 1e and start task 1f after a seven hour mobilization period. P.O.L. supplies to these "by-passing" groups could be carried in drums by crawler front-end loaders. It is recognized that maintenance of "by-passing" groups

SAN FRANCISCO STUDY
DEBRIS REMOVAL
BAR CHART

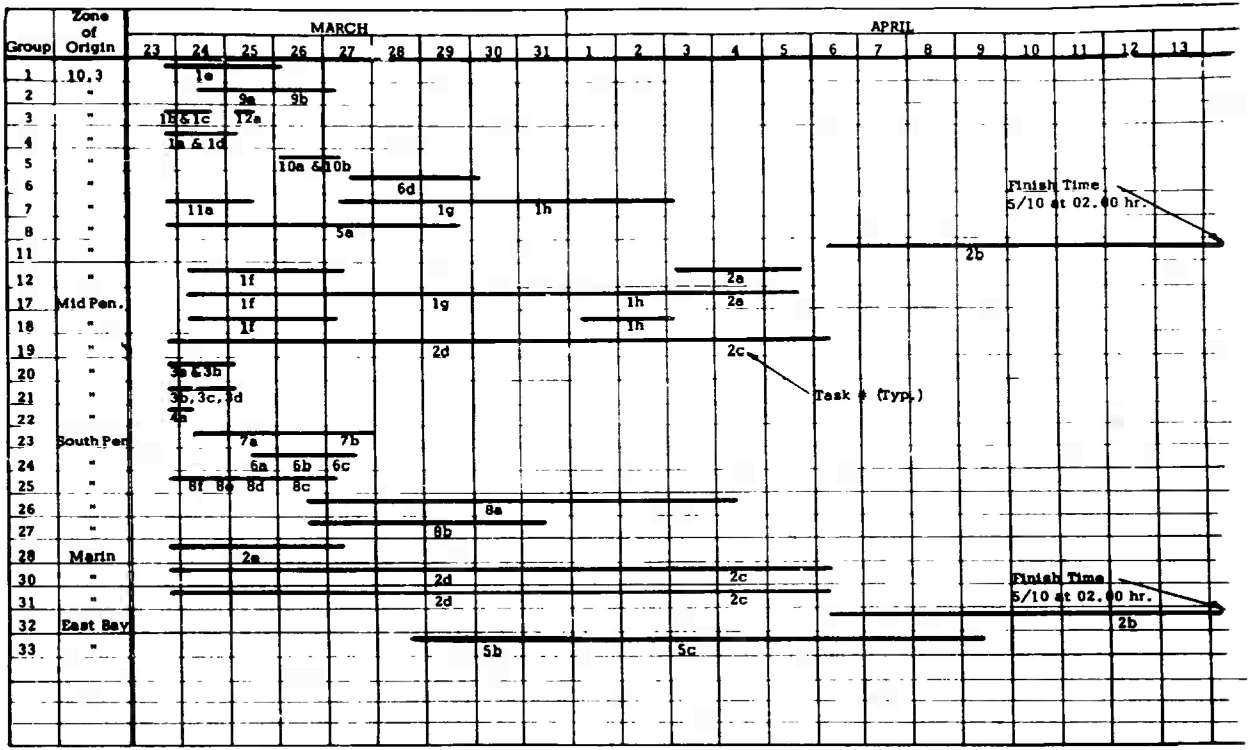

Figure 11.15

would be difficult. In this study, another method of both mobilization to a task and of P.O.L. supply during the task was considered. This was by use of barges on water routes. Of course, this method would not be applicable to all cities.

11.6 TOTAL REQUIRED RESOURCES

On completion of the "Resource Assignment" for all tasks, the Total Resource Needs Forecast, Figure 11.16, was compiled. This card shows a prediction of total manpower hours, by skills, and total petroleum fuel requirements for clearing the 12 routes through the City. Comparing the P.O.L. quantities with the P.O.L. resources available in the area, as indicated on the P.O.L. Sources Card (Figure 11.8) shows that only a small fraction of these resources will be needed fo: debris clearing operations.

From the Equipment Group Cards and Task Requirement Cards, a total Machine Hour Forecast was made. Figure 11.17 shows this forecast for routes 8, 9, 10, 11 and 12. The hours shown as B/F (Brought Forward) are for routes 1 through 7.

It is interesting to note the following: 71,385 manhours, requiring a maximum of approximately 300 men are needed to remove 548,525 cu.yd. of debris material. All tasks except 2b would be finished after 17 days. Finish of task 2b would be approximately 48 days after the start of clearing operations on March 23. To clear the 12 assigned routes, 85 pieces of major or key equipment and 7 cranes are required. This equipment, along with the necessary dump trucks, will require approximately 195,000 gallons of diesel fuel.

TOTAL RESOURCE NEEDS FORECAST

DATE: 3/25/71

CITY: San Francisco AREA All City

Task	Equip. Groups	Debris Volume (cu.yds)	Labor Hours by skill				POL Total			
			1	2	3	4	Dies Gal.	Gas Gal.	Lube Lb.	Oil Gal.
1	4,3,1 12,7,17 &18	89,595	2,250	1,052	5,563	2,082	31,695	905	1,960	626
2	17,12,11 32,38,30 31 & 19	240,055	8,367	3,408	24,611	6,058	120,252	3,460	7,374	2,495
3	20 & 21	22,560	183	64	133	283	2,580	45	128	45
4	22	5,125	36	12	29	60	508	10	25	10
5	8 & 33	40,855	977	556	3,052	1,184	16,964	408	825	300
6	6 & 24	20,410	218	80	480	375	2,923	87	157	68
7	23	11,995	164	71	359	246	2,712	68	136	68
8	25,26,27	65,540	996	422	2,415	1,246	13,339	415	812	315
9	2	17,275	142	47	210	226	1,825	21	142	36
10	5	4,265	64	9	120	64	504	20	29	12
11	7	8,630	117	51	252	195	1,445	55	98	43
12	3	2,220	12	4	14	24	187	4	10	4
Total		548,525	13,526	5,776	40,040	12,043	194,934	5,498	11,696	4,022

Figure 11.16

EQUIPMENT RESOURCE

TOTAL MACHINE HOUR FORECAST

DATE: 2/24/71

ZONE OR TOTAL: San Francisco

Task or Zone	Equipment Code															
	288	286	284	280	169	167	165	166	162	176	072					
B/F	1511	909	203	698	162	1938	2018	125	1480	309	2747					
8a	211					211					148					
8b	115					115					58					
8c	34															
8d	24															
8e	24															
8f	56															
9a		42							42							
9b		29							29							
10a			11	11												
10b			21	21												
11				39	39											
12		12														
TOTAL	1975	992	235	769	201	2264	2018	125	1551	309	2953					

Figure 11.17

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SECTION 12
CONCLUSIONS AND RECOMMENDATIONS

12.1 CONCLUSIONS

Debris environments and associated debris clearing problems are very difficult to predict. It is possible, however, to make realistic approximations by utilizing and combining findings of previous research (References 1-7) with procedures set forth in this study. Clearing operations and resource requirements can be evaluated on the basis of different simulated attack conditions during the pre-event planning period. The proposed procedures are such that post-attack data could be readily integrated without significantly altering the overall concept.

12.1.1 Mobilization

Success of any emergency action depends to a large extent on an efficient and reliable method of mobilizing necessary resources. Debris clearing operations are no exception, even though they present problems which are not applicable to other activities, such as need for large size construction equipment. The study proposes various inventory and organizational procedures to be followed in planning or periods of increased readiness and by which resources can be mobilized for clearing operations. Specific requirements for successful mobilization will depend on local conditions and emergency operating plans if available. In any event, it is essential that mobilization procedures be finalized in the planning period.

12.1.2 Available Resources

Based on existing studies and assumed attack conditions it appears that sufficient resources would be available to implement clearing operations

in the post-attack period. Resources can be assigned to different clearing tasks on the basis of their availability and capacity of handling various types of debris. Evaluations can be made for different areas and attack conditions so as to identify those situations where lack of resources would preclude the initiation of clearing operations.

12.1.3 Total Effort

Total effort in terms of manpower, equipment, P.O.L. supplies and other supporting resources can be determined for various debris clearing operations. They will provide a guide as to potential need and use of resources for this particular emergency function. Approximations of total resource requirements for all simulated conditions can be made by relating anticipated quantities of debris generated by those situations to debris quantities considered in specific case studies.

12.1.4 Case Study

The San Francisco case study shows that the proposed methods and procedures would provide essential data and information needed in both pre-attack planning and post-attack implementation of debris clearing operations. The indicated formats are adaptable to specific requirements of a study area subjected to different attack conditions. They provide a means by which evaluation of clearing operations can be made with respect to the overall recovery effort.

12.2 RECOMMENDATIONS

Debris clearing operations are a critical function to be considered in any emergency operating plan. In many instances, other Civil Defense actions cannot be initiated until debris clearing is accomplished. Based on

conclusions and findings of this study, the following recommendations are made:

a) Formats and inputs used in developing the proposed operational plan should be reviewed with respect to existing Emergency Operating Plans, such as "NEOP" proposed by Stanford Research Institute. Debris clearing should be considered as a separate "annex" or emergency action.

A formalized "handbook" for making predictions of debris environments and the implementation of clearing operations should be prepared. It must be adaptable to all study areas and presented in such a form that local Civil Defense personnel could analyze and evaluate potential requirements and effectiveness of clearing operations.

b) Additional investigations should be made regarding mobilization efforts required for clearing operations during periods of increased readiness. Correlation with other emergency functions--the effectiveness of MSA concept with respect to clearing operations--and evaluation of resource allocations between different functions should be studied.

c) Due to interdependency of all survival actions, it is recommended that additional effort be made to define more specifically the "critical time relation" between clearing operations and other functions such as fire fighting, evacuation, etc.

d) Factors or parameters should be developed by which the proposed debris clearing operational plan could be adapted to natural disasters such as floods or hurricanes.

APPENDIX A

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